

Executive Office of Environmental Affairs Massachusetts Watershed Initiative



Mumford River Low Flow Study

FIGURES & APPENDICES



Prepared By:
Gomez and Sullivan
Engineers and Environmental Scientists
55 North Stark Highway
Weare, NH 03281
603-529-4400, gomezandsullivan.com

Final Report, November 2003

General Location of the Mumford River Watershed

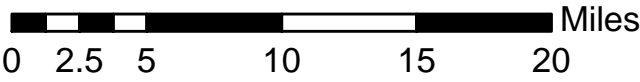
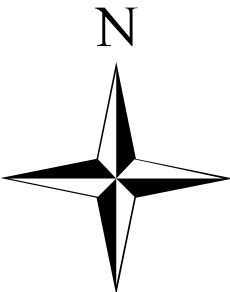
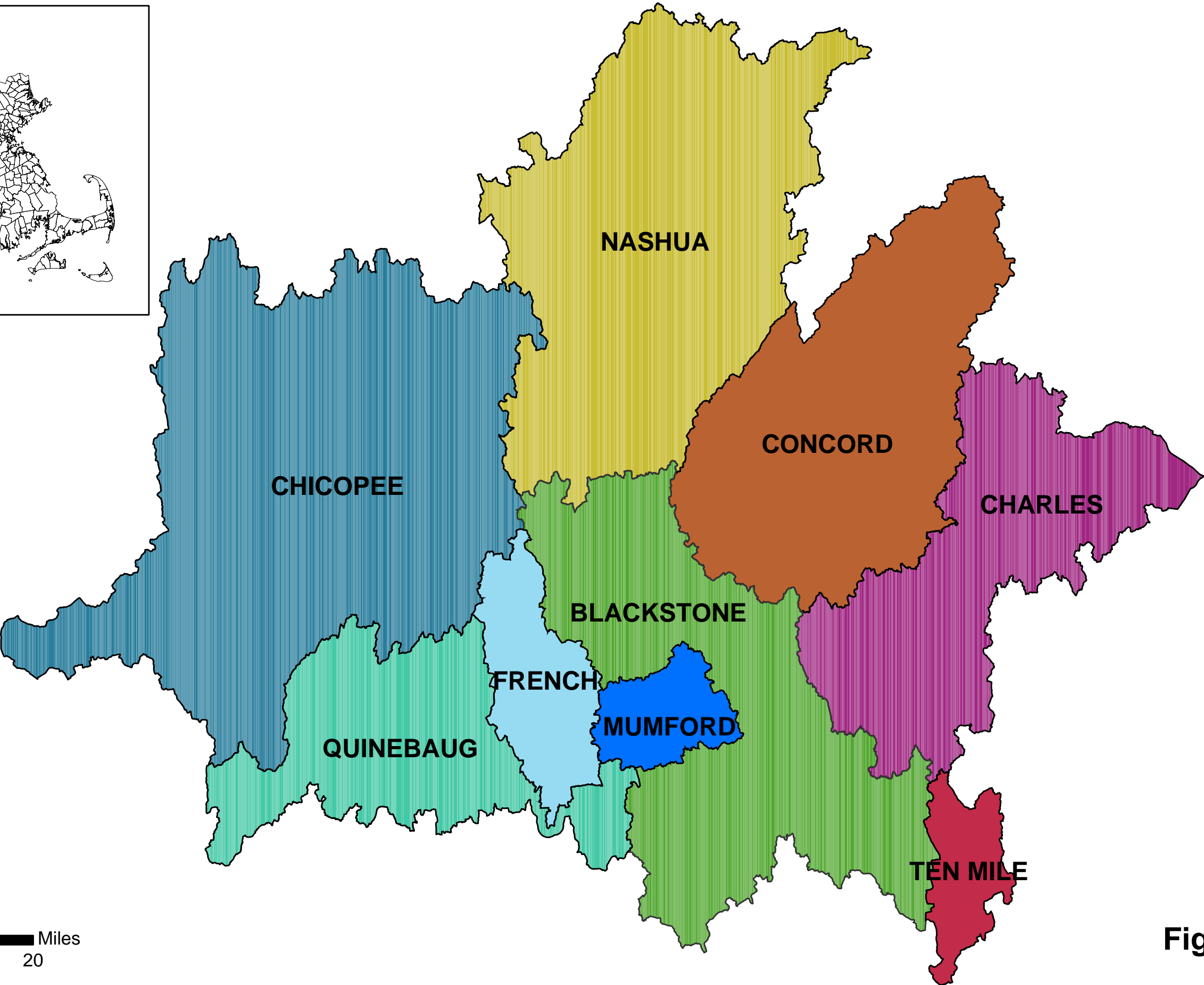
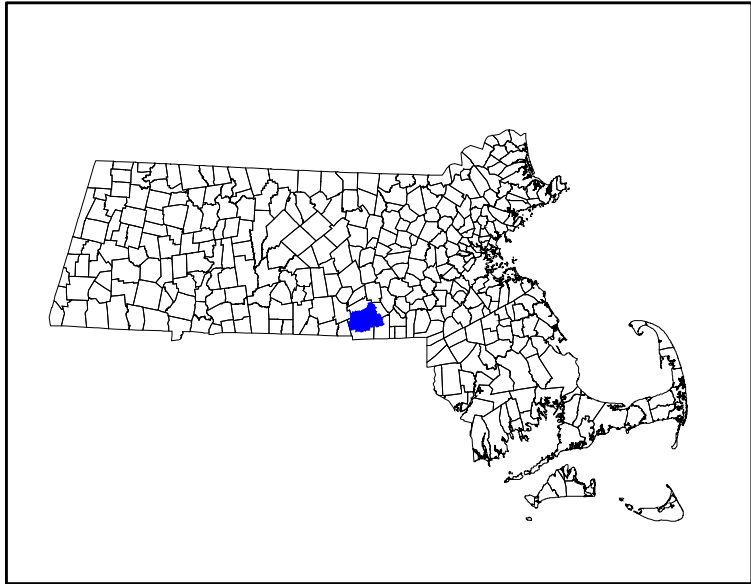
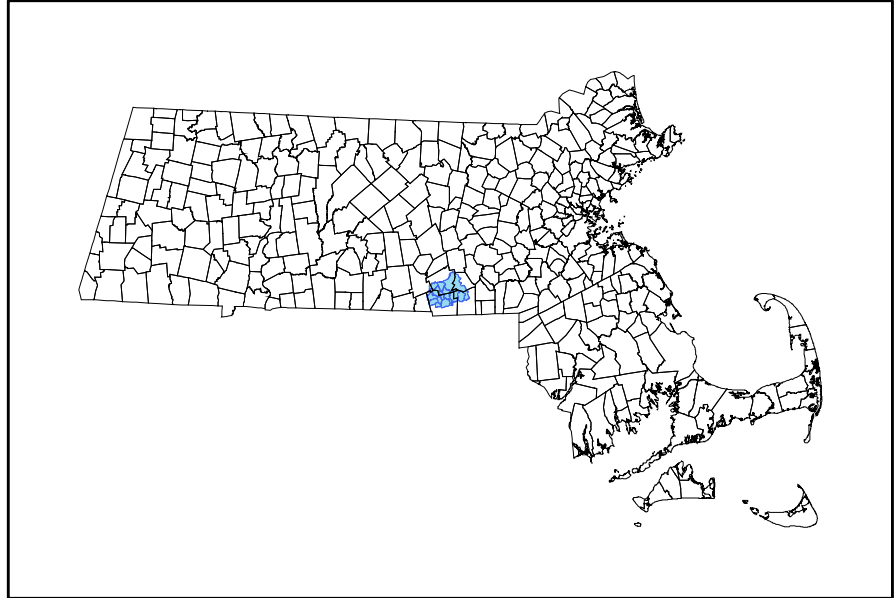


Figure E-1

Base Map of the Mumford River Watershed



Legend

- Staff gage
- Dams
- Town Boundaries
- East Douglas WWTP (NPDES Discharge)
- Interface Fabrics Finishing (NPDES Discharge)
- Interface Fabrics Finishing
- Whitinsville Water Company-(Cook Allen Brook Tubular Wellfield)
- Whitinsville Water Company-(Gravel Packed Wellfield)
- Whitinsville Water Company-(Meadow Pond)
- Whitinsville Water Company-(Meadow Pond Tubular Well Field)
- Douglas Water Company-(Glenn St. Well #1)
- Douglas Water Company-(Glenn St. Well #2)
- Douglas Water Company-(West St. Gravel Packed Well)
- Douglas Water Company-(West St. Tubular Wellfield)
- Major Lakes and Ponds
- Major Rivers and Streams
- Zone 2 Wellhead Protection Area
- Watershed Boundary
- Golf Course

N

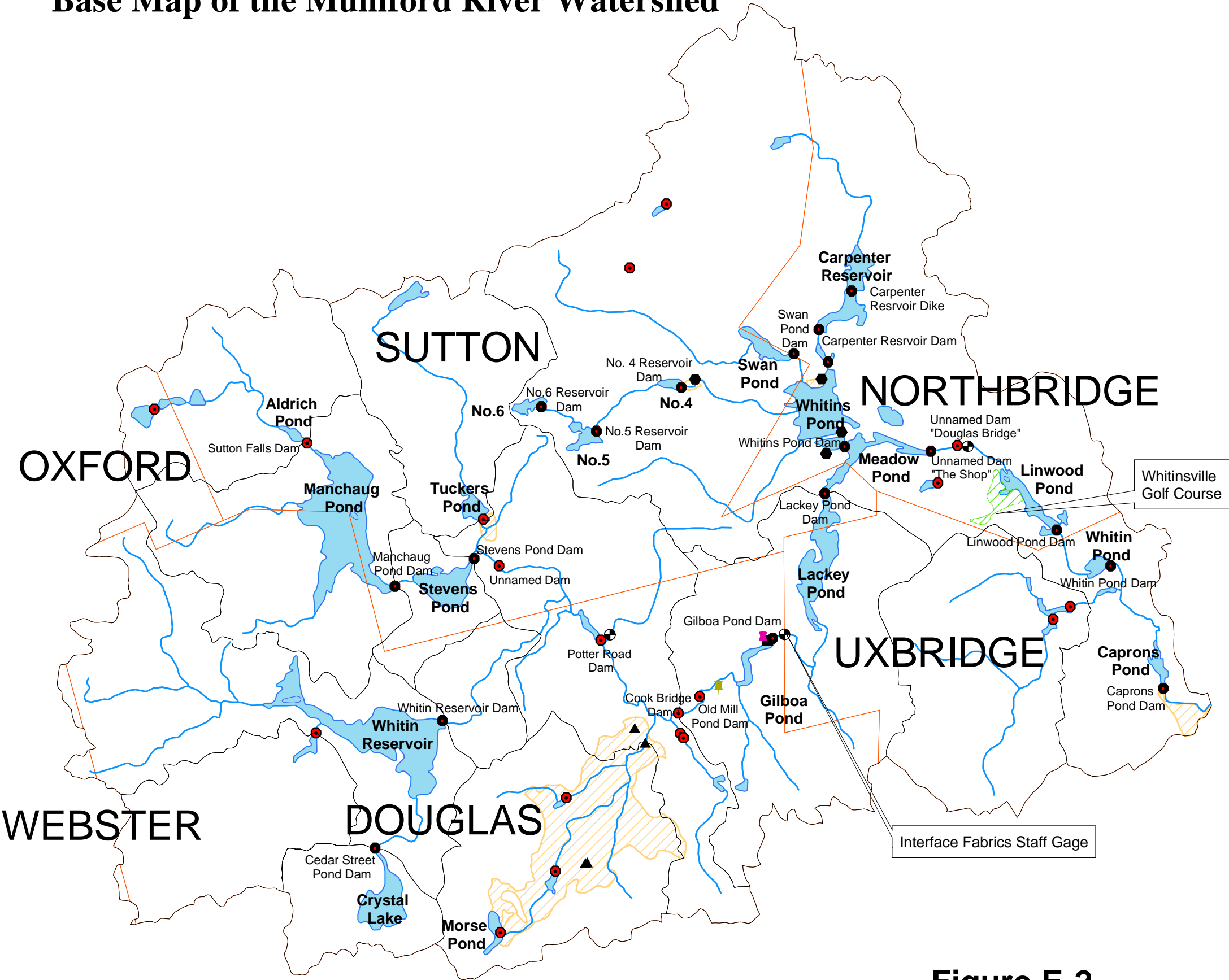
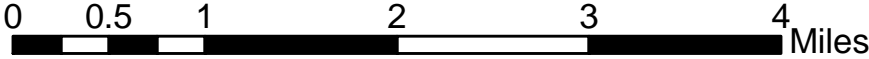


Figure E-2



Staff Gages Located in the Mumford River Watershed

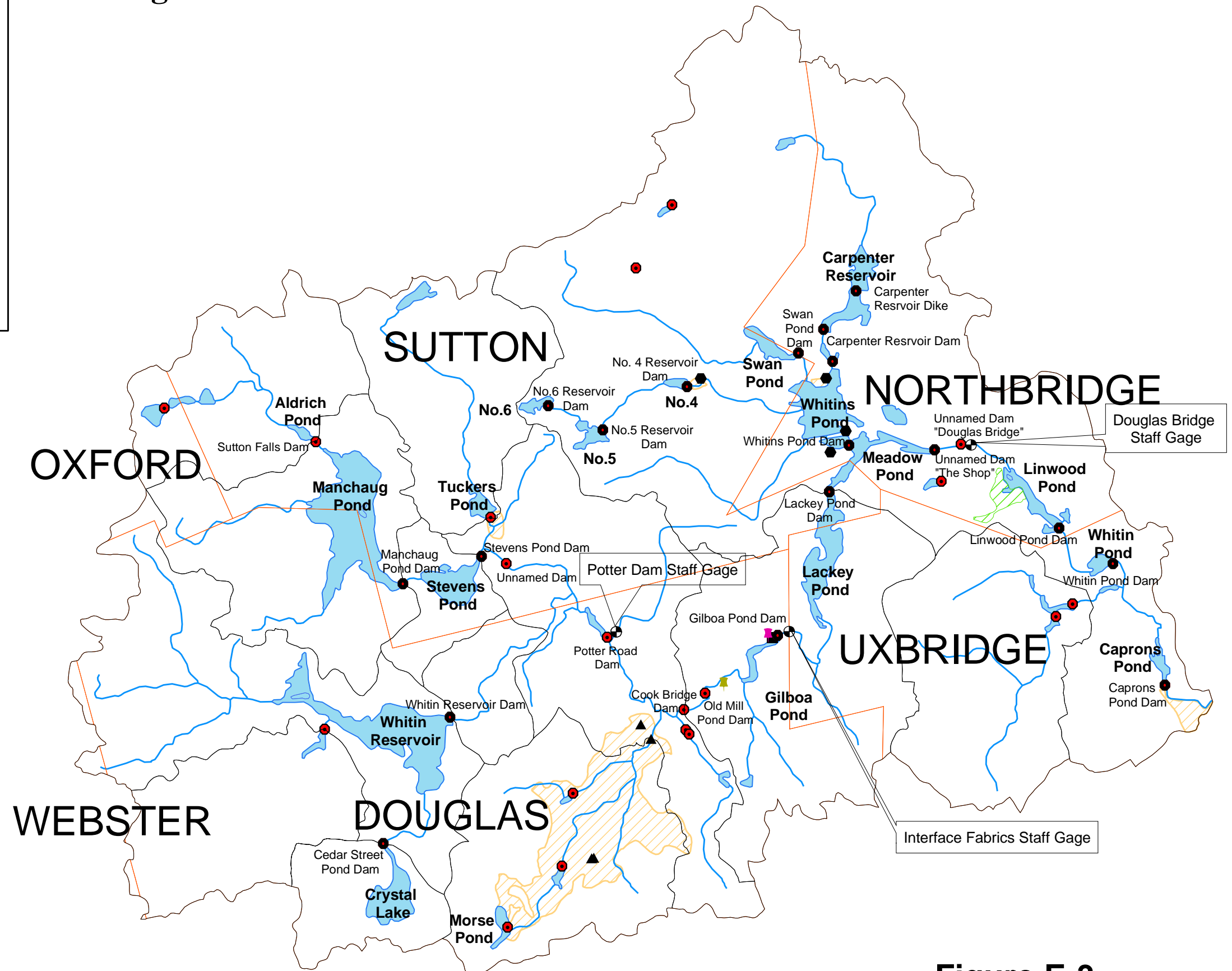
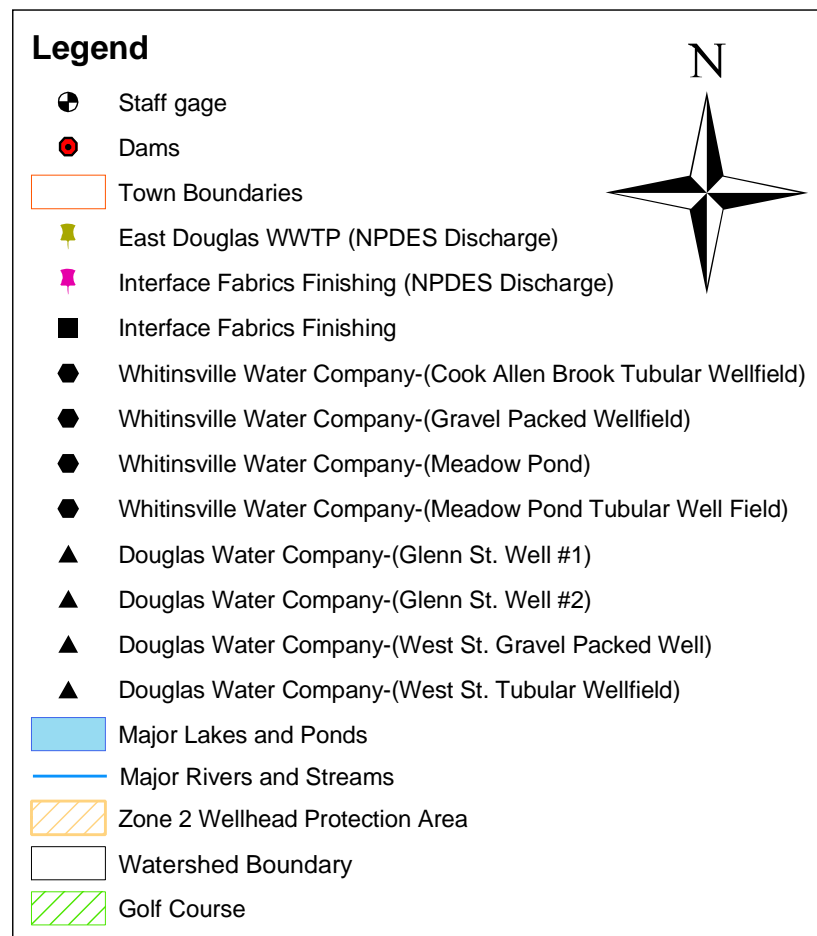
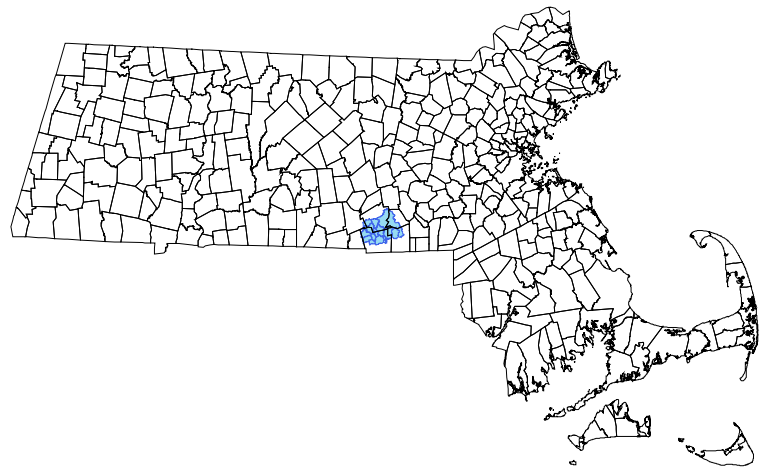


Figure E-3

General Location of the Mumford River Watershed

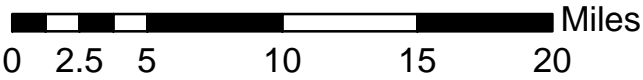
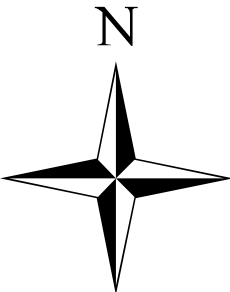
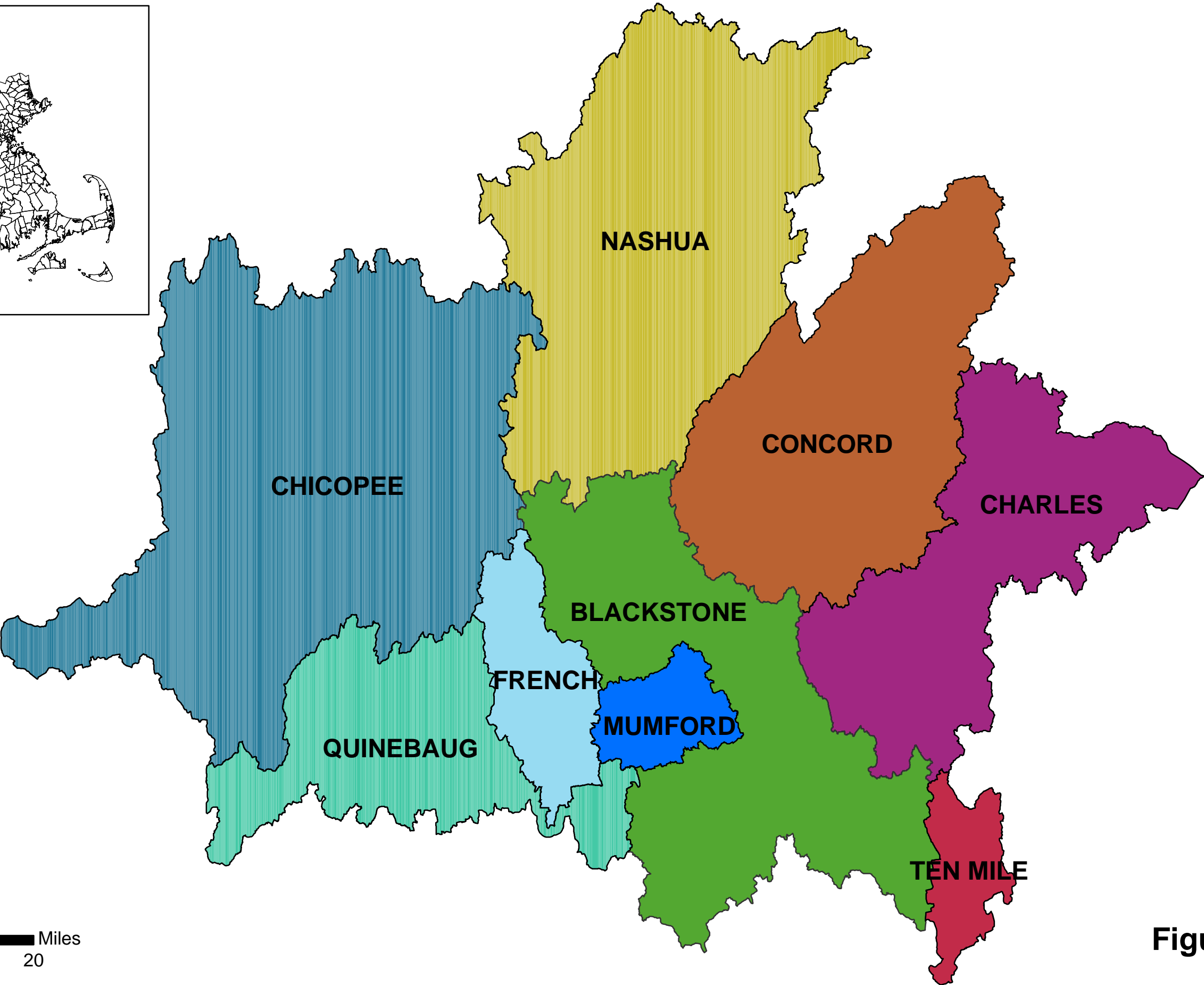
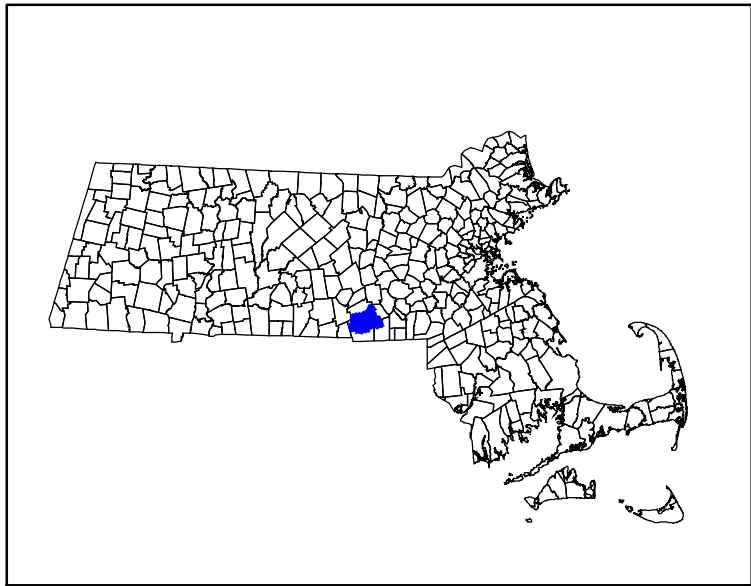
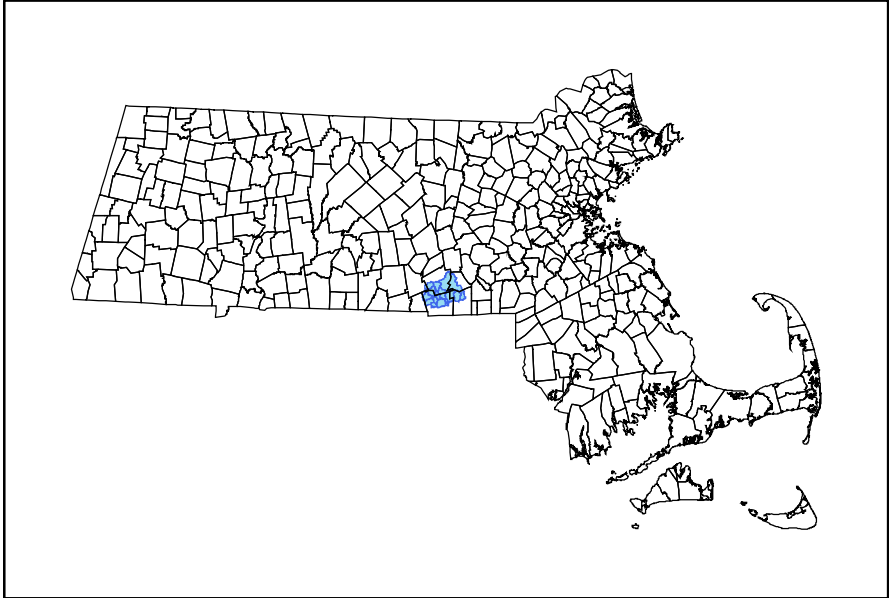


Figure 1.0-1

Base Map of the Mumford River Watershed



Legend

- Staff gage
- Dams
- Town Boundaries
- East Douglas WWTP (NPDES Discharge)
- Interface Fabrics Finishing (NPDES Discharge)
- Interface Fabrics Finishing
- Whitinsville Water Company-(Cook Allen Brook Tubular Wellfield)
- Whitinsville Water Company-(Gravel Packed Wellfield)
- Whitinsville Water Company-(Meadow Pond)
- Whitinsville Water Company-(Meadow Pond Tubular Well Field)
- Douglas Water Company-(Glenn St. Well #1)
- Douglas Water Company-(Glenn St. Well #2)
- Douglas Water Company-(West St. Gravel Packed Well)
- Douglas Water Company-(West St. Tubular Wellfield)
- Major Lakes and Ponds
- Major Rivers and Streams
- Zone 2 Wellhead Protection Area
- Watershed Boundary
- Golf Course

N

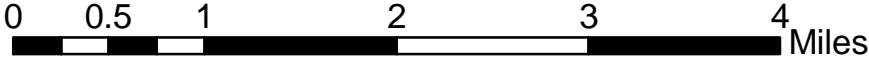
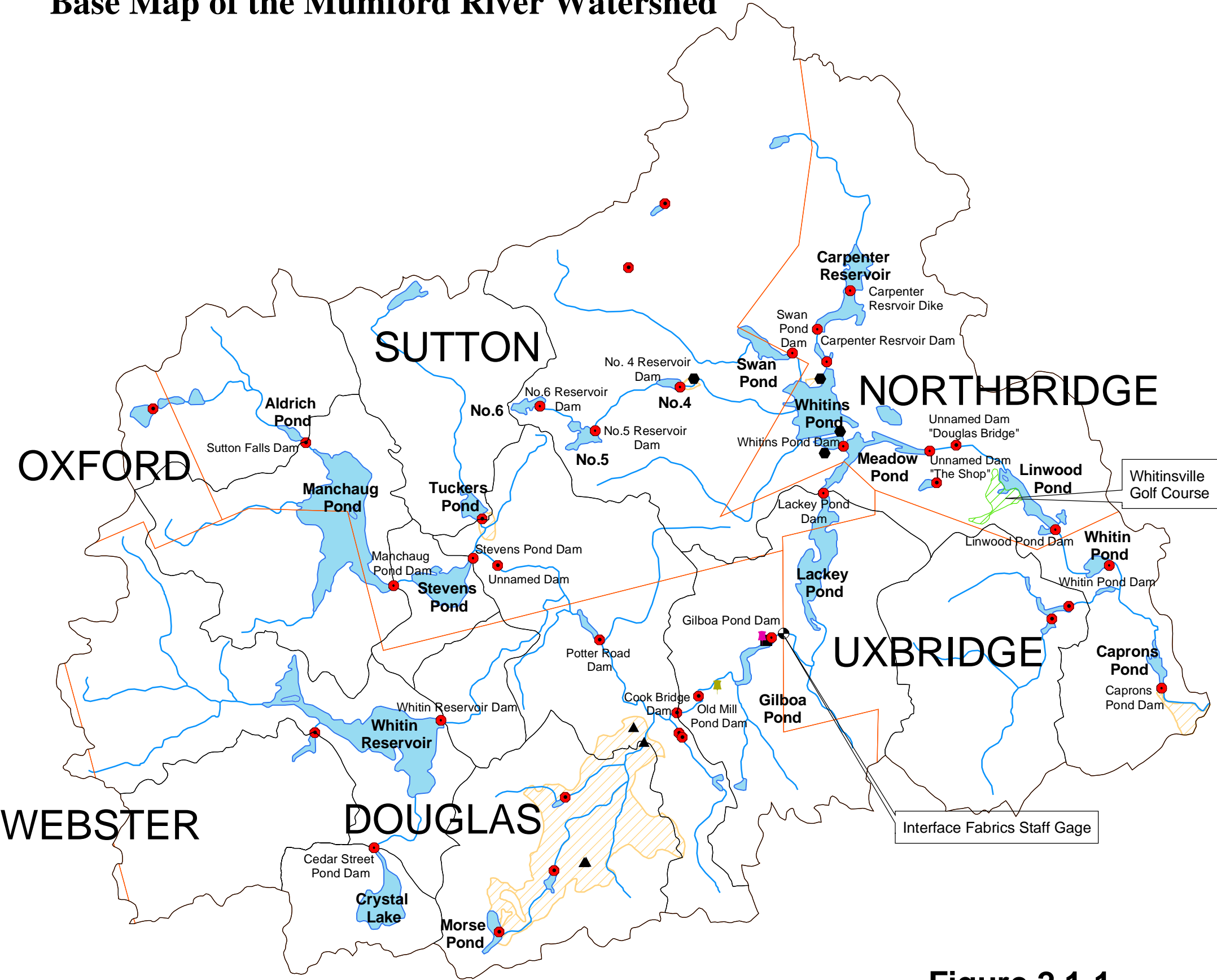
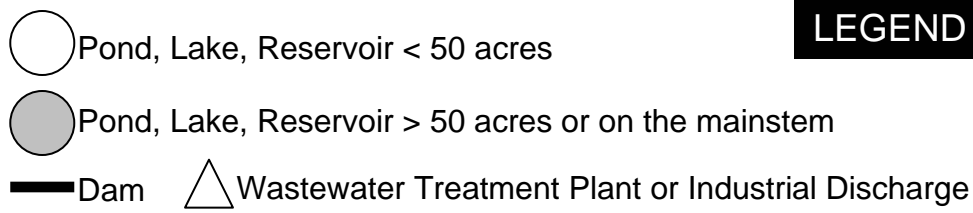


Figure 2.1-1

FIGURE 2.1-2: SCHEMATIC OF MUMFORD RIVER BASIN



NOT TO SCALE

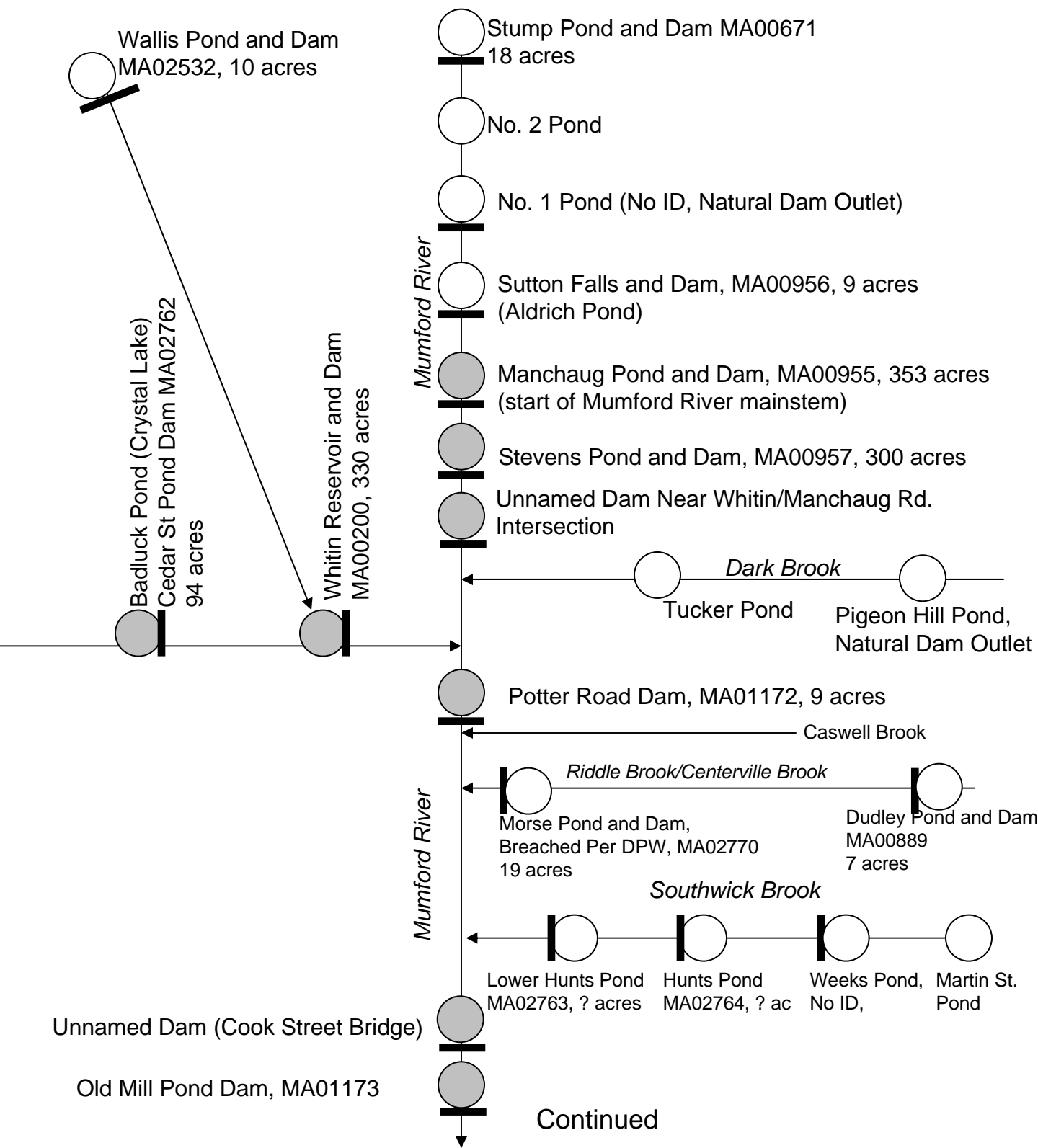
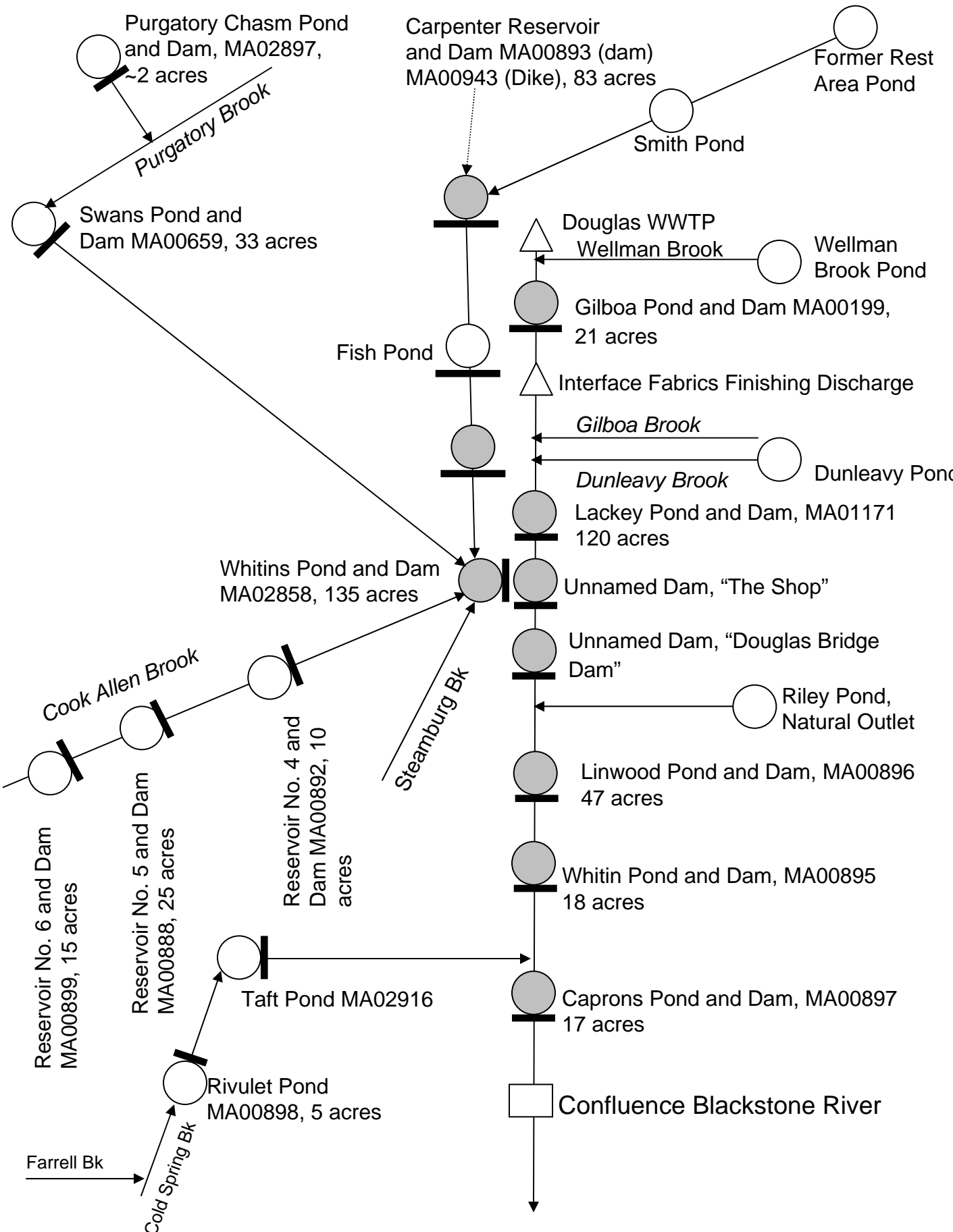


FIGURE 2.1-2: SCHEMATIC OF MUMFORD RIVER BASIN (cont)



Topographic Relief of the Mumford River Watershed

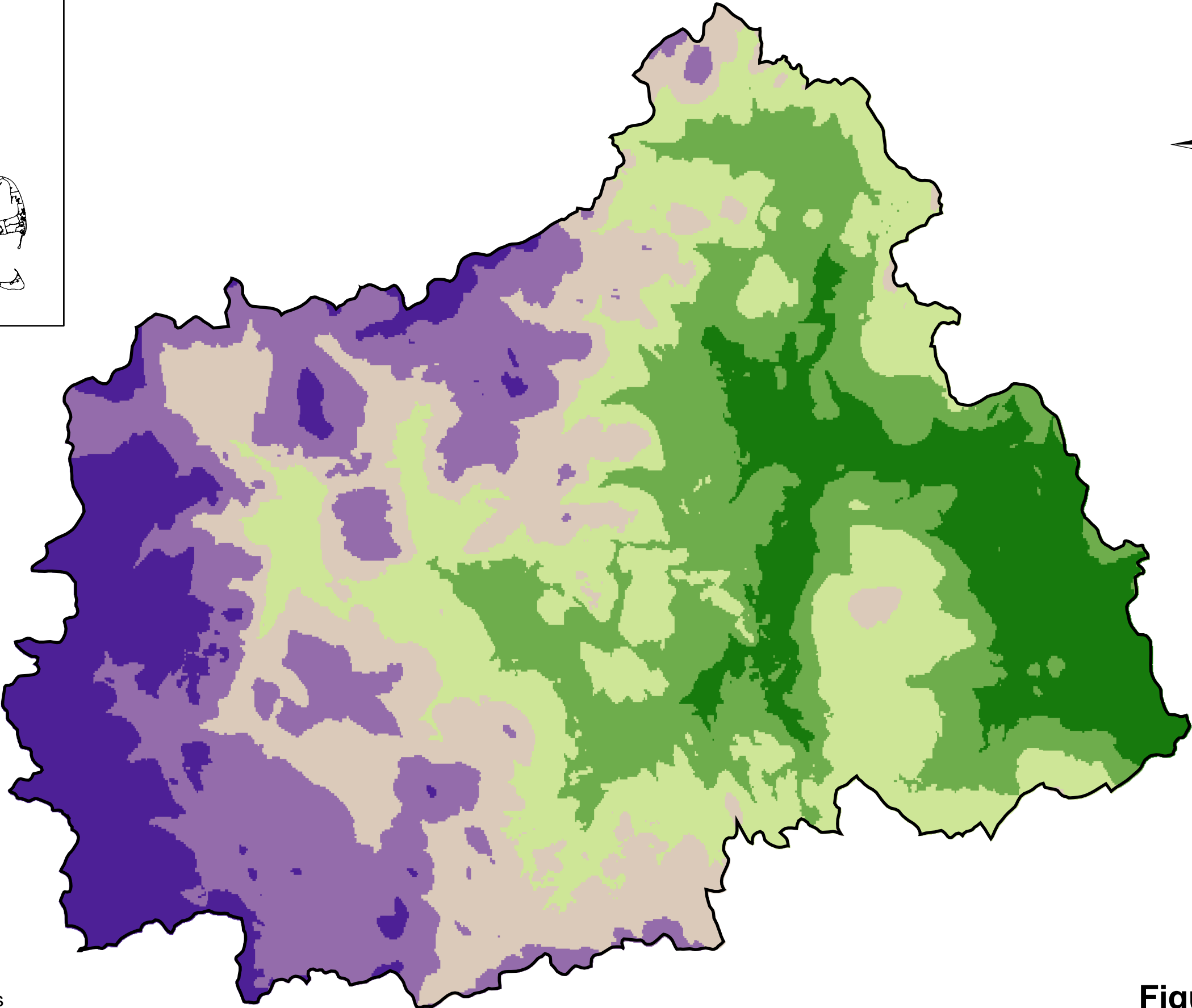
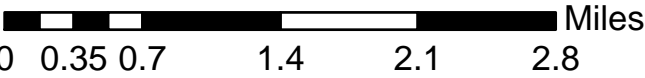
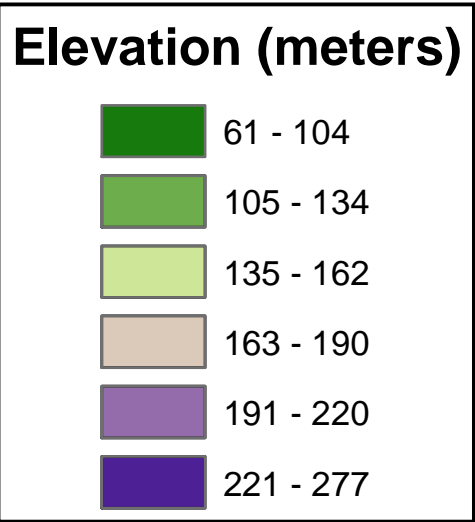
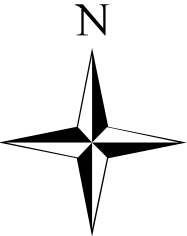
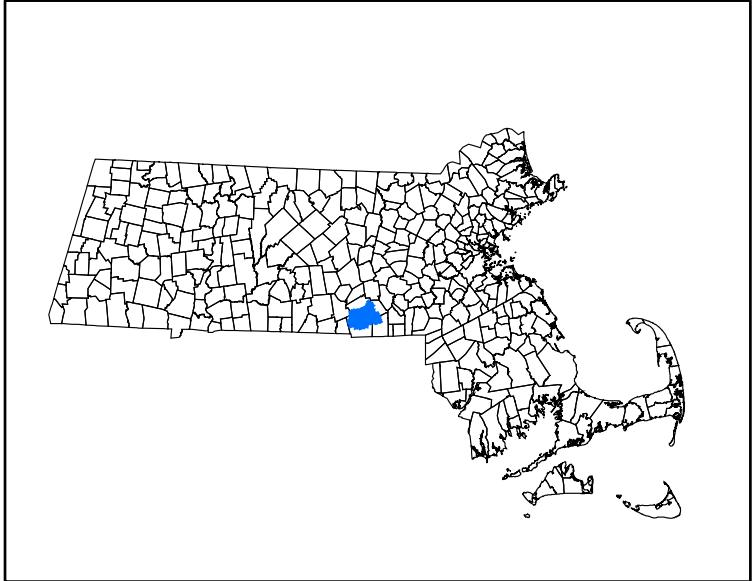
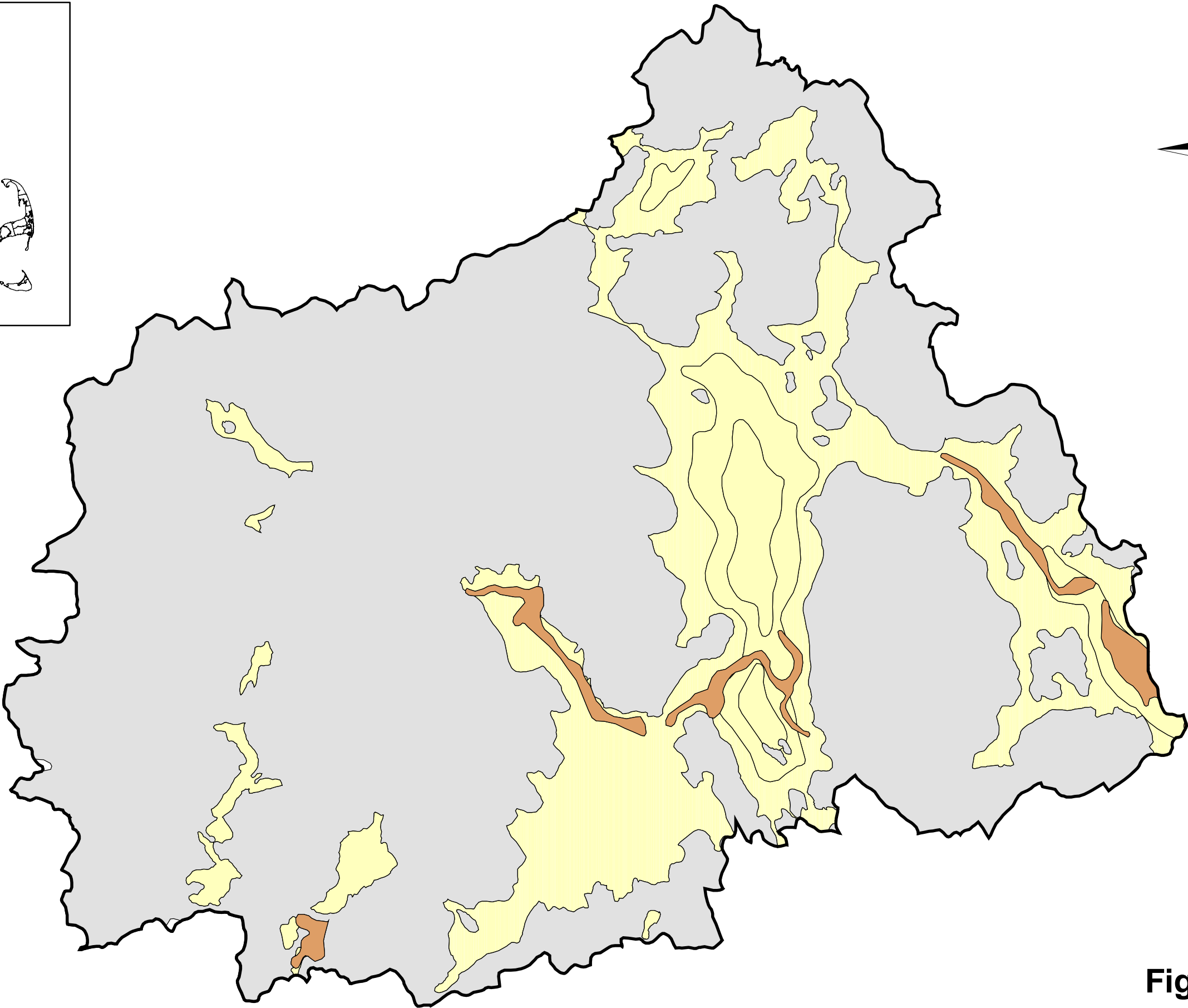
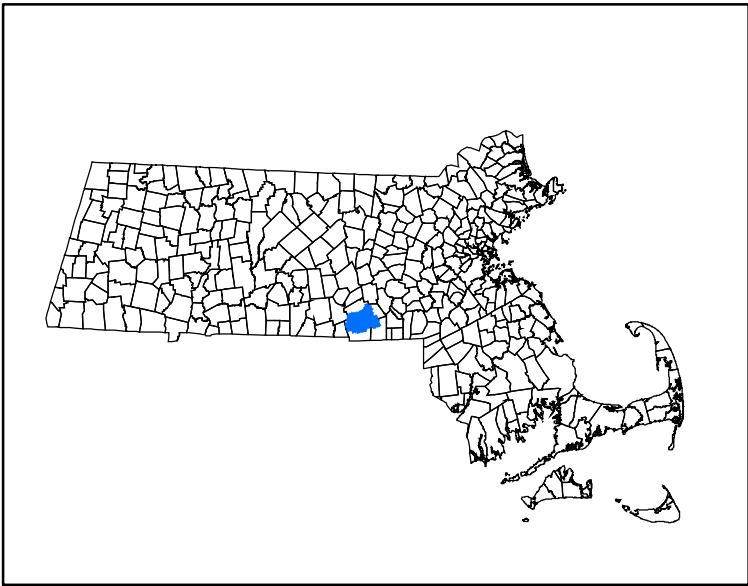
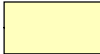




Figure 2.2-1

Surficial Geology of the Mumford River Watershed



Surficial Geology

	Sand and Gravel
	Till or Bedrock
	Floodplain Alluvium

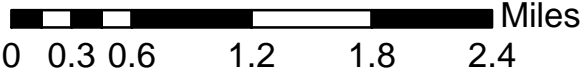
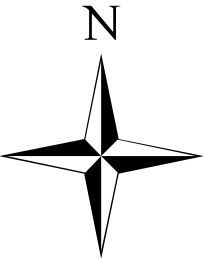
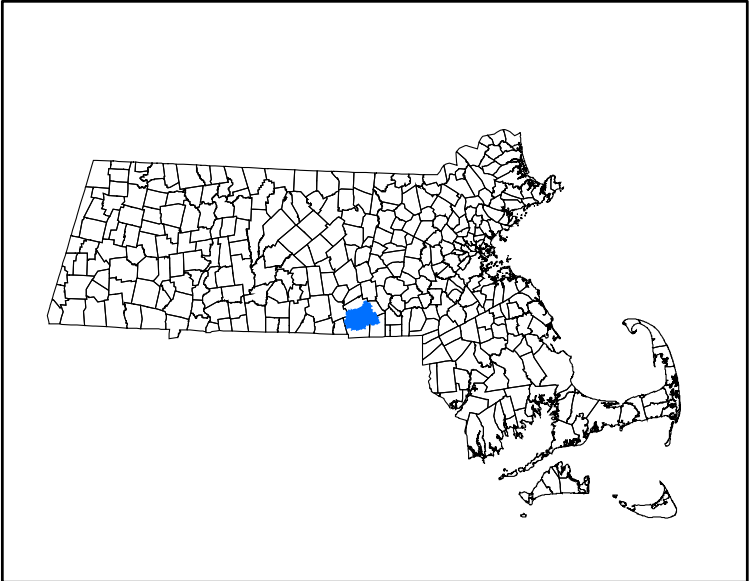



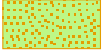




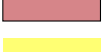


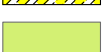





Figure 2.3-1

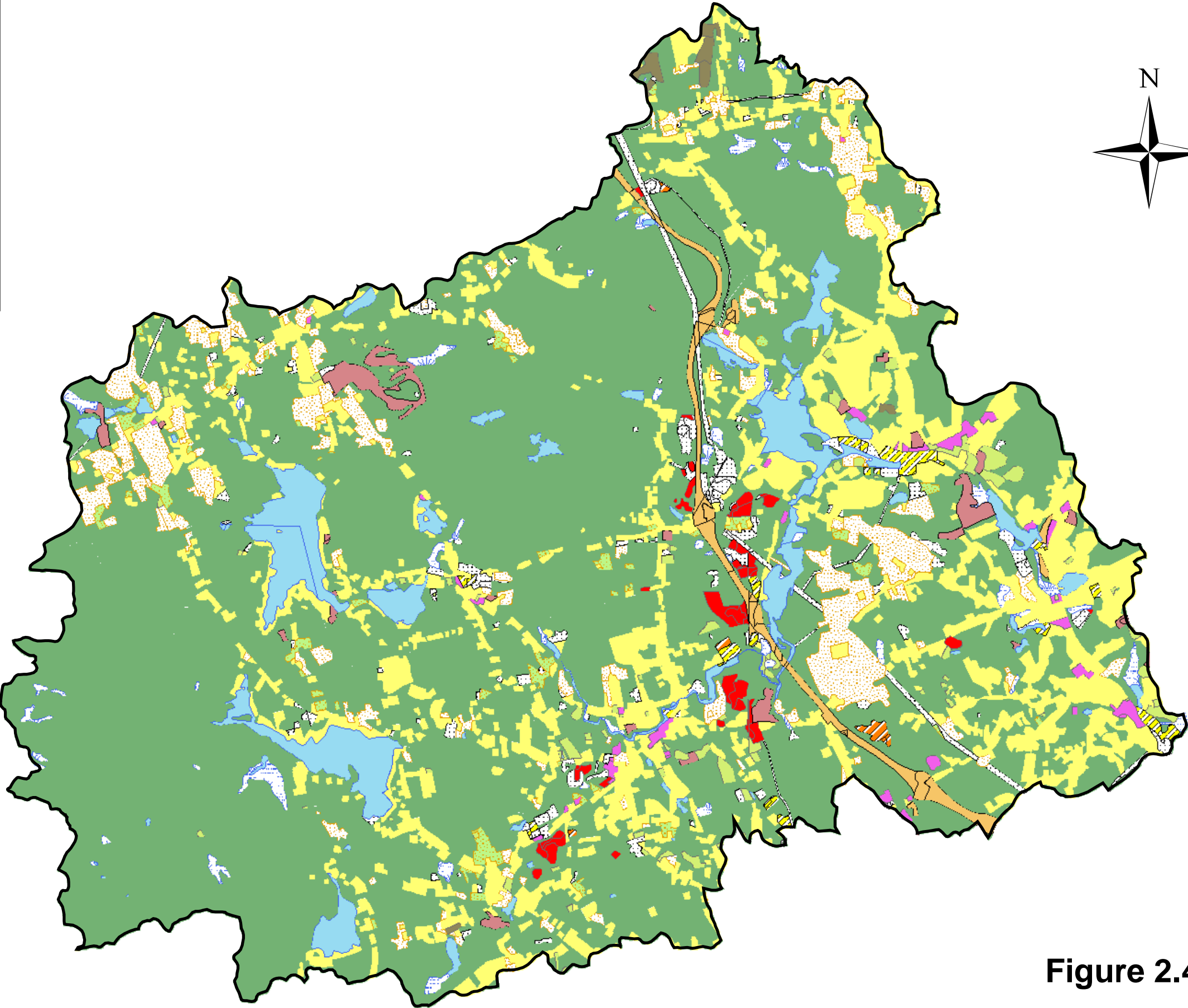
Land Use in the Mumford River Watershed (1999 Data)



Land Use Type

Land Use Type

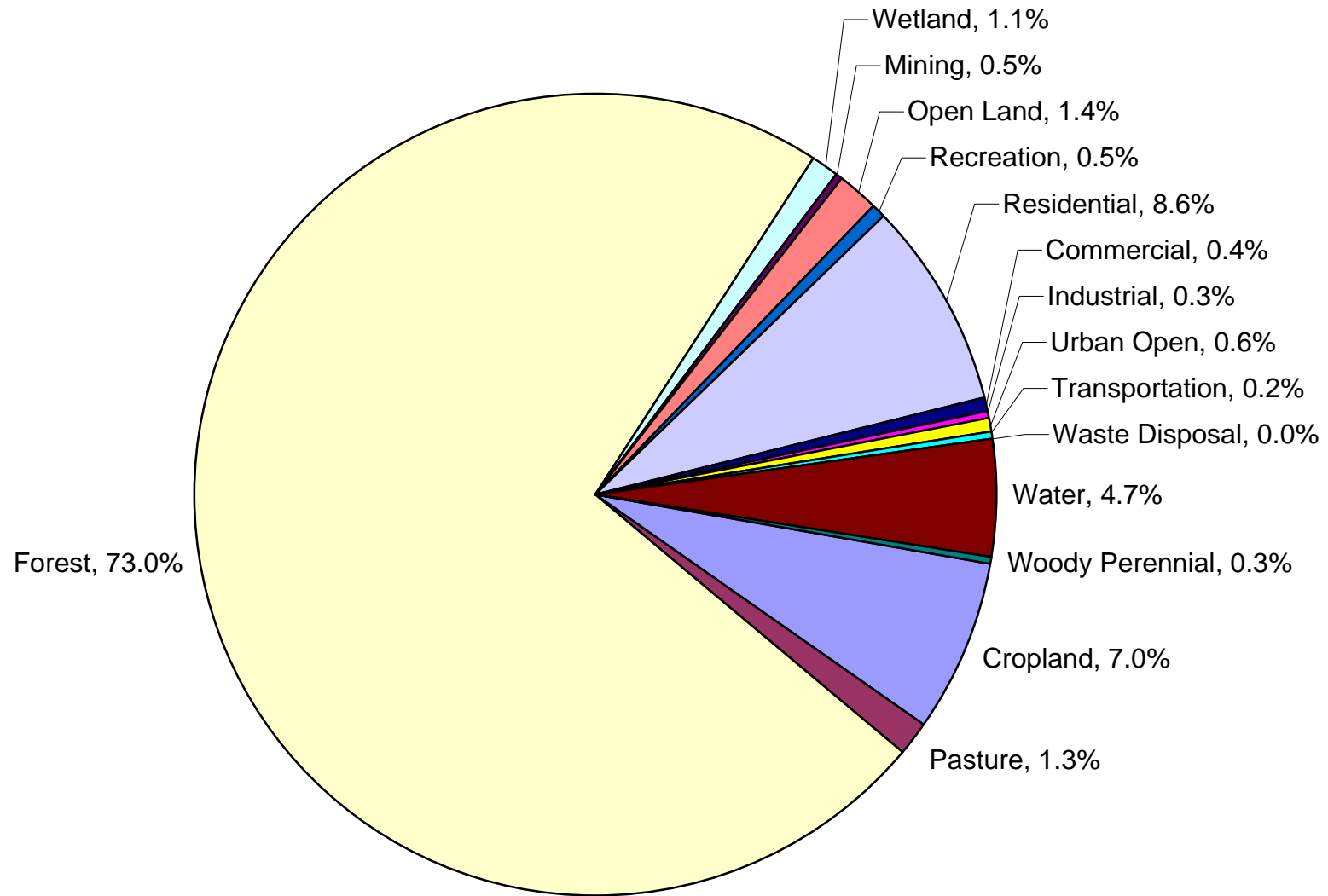
-  Cropland
-  Pasture
-  Forest
-  Wetland
-  Mining
-  Open Land
-  Recreation
-  Residential
-  Commercial
-  Industrial
-  Urban Open
-  Transportation
-  Waste Diposal
-  Water
-  Woody Perennial



0 0.3 0.6 1.2 1.8 2.4 Miles

Figure 2.4-1

1971 Land Use within the Mumford River Watershed



Source: Mass GIS

FIGURE 2.4-2

1999 Land Use within the Mumford River Watershed

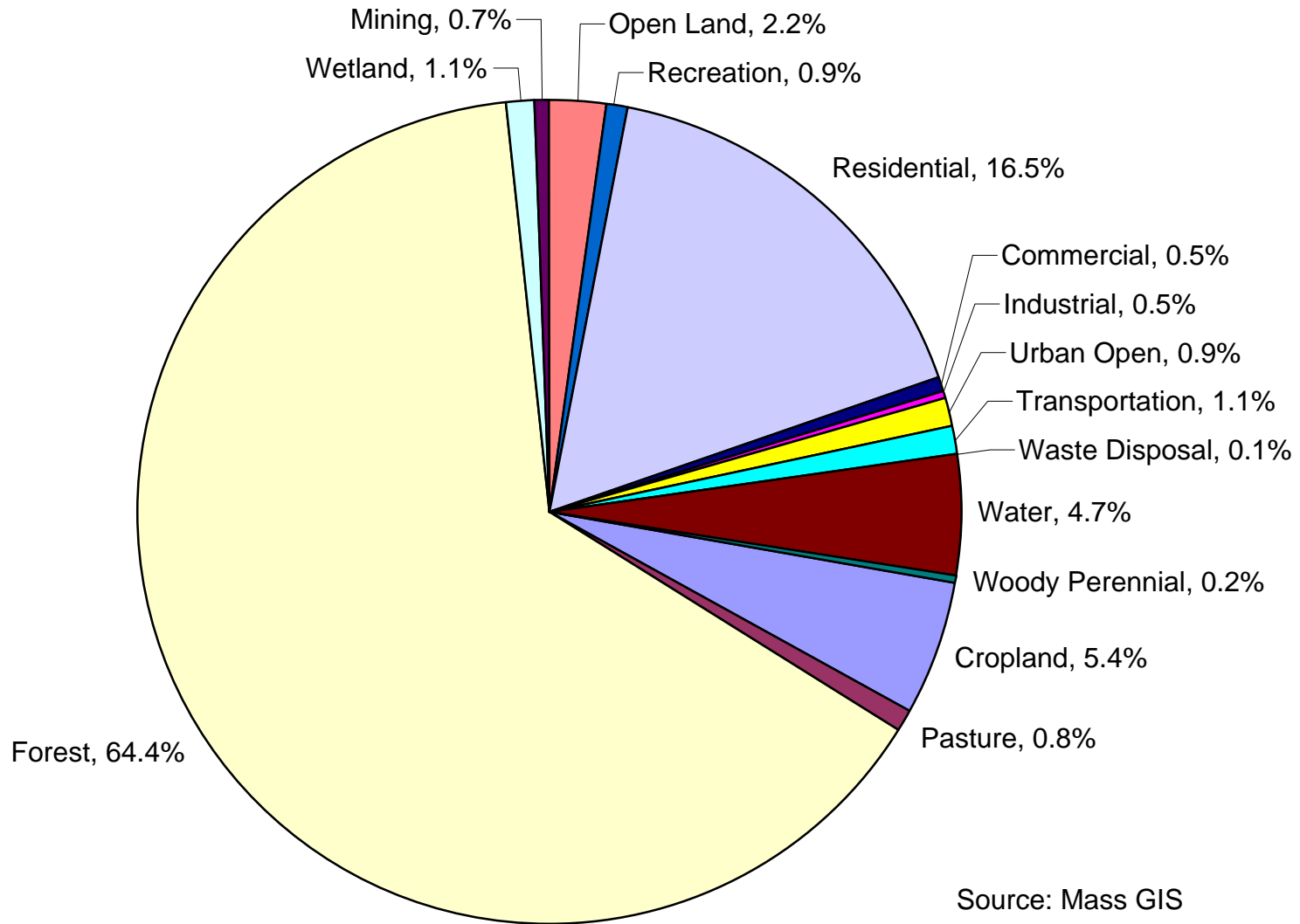


FIGURE 2.4-3

Change in Land Use within the Mumford River Watershed

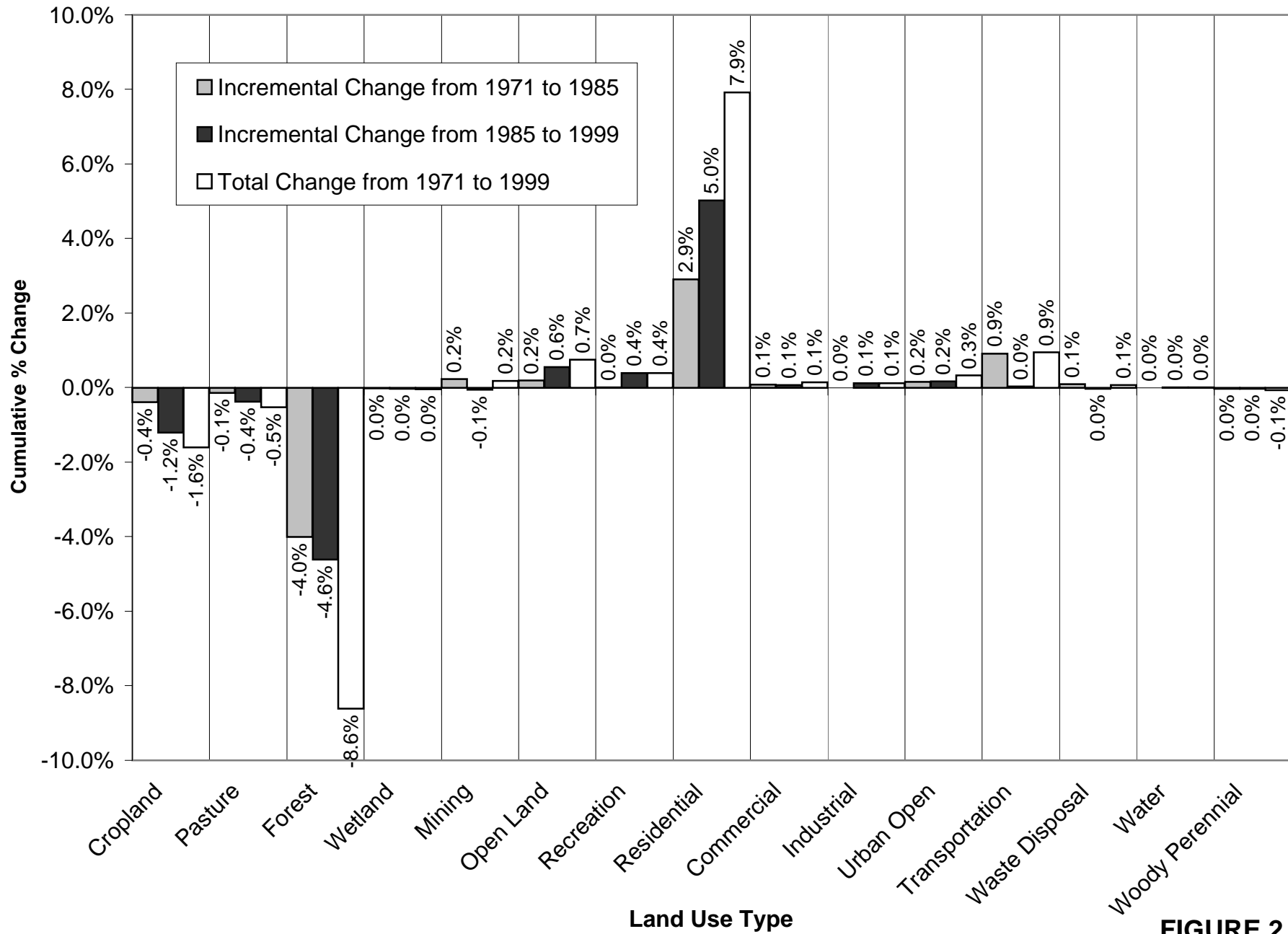
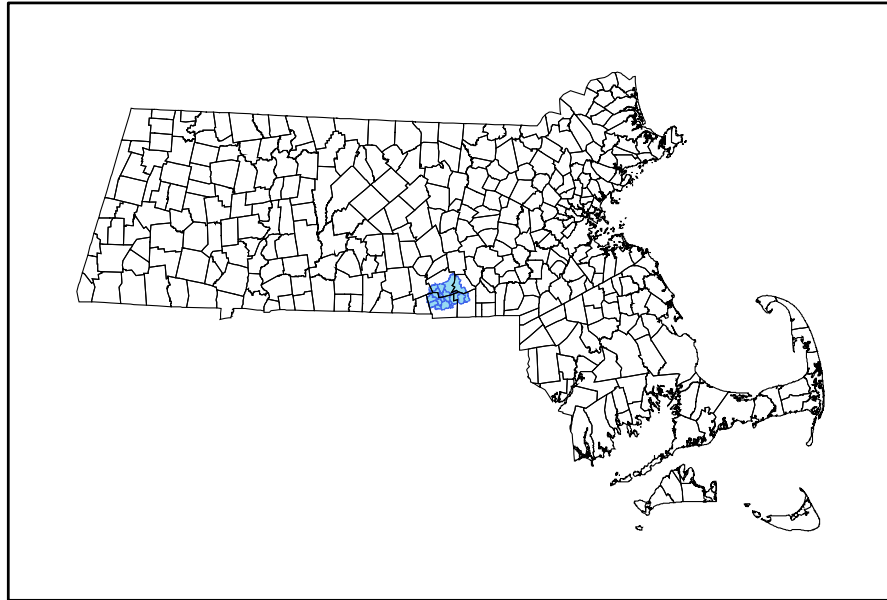


FIGURE 2.4-4

Location of Precipitation Gages in the Mumford River Watershed (Northbridge, Uxbridge)



Legend

-  Precipitation Gages
-  Town Boundaries
-  Major Lakes and Ponds
-  Major Rivers and Streams
-  Zone 2 Wellhead Protection Area
-  Watershed Boundary
-  Golf Course

0 0.5 1 2 3 4 Miles

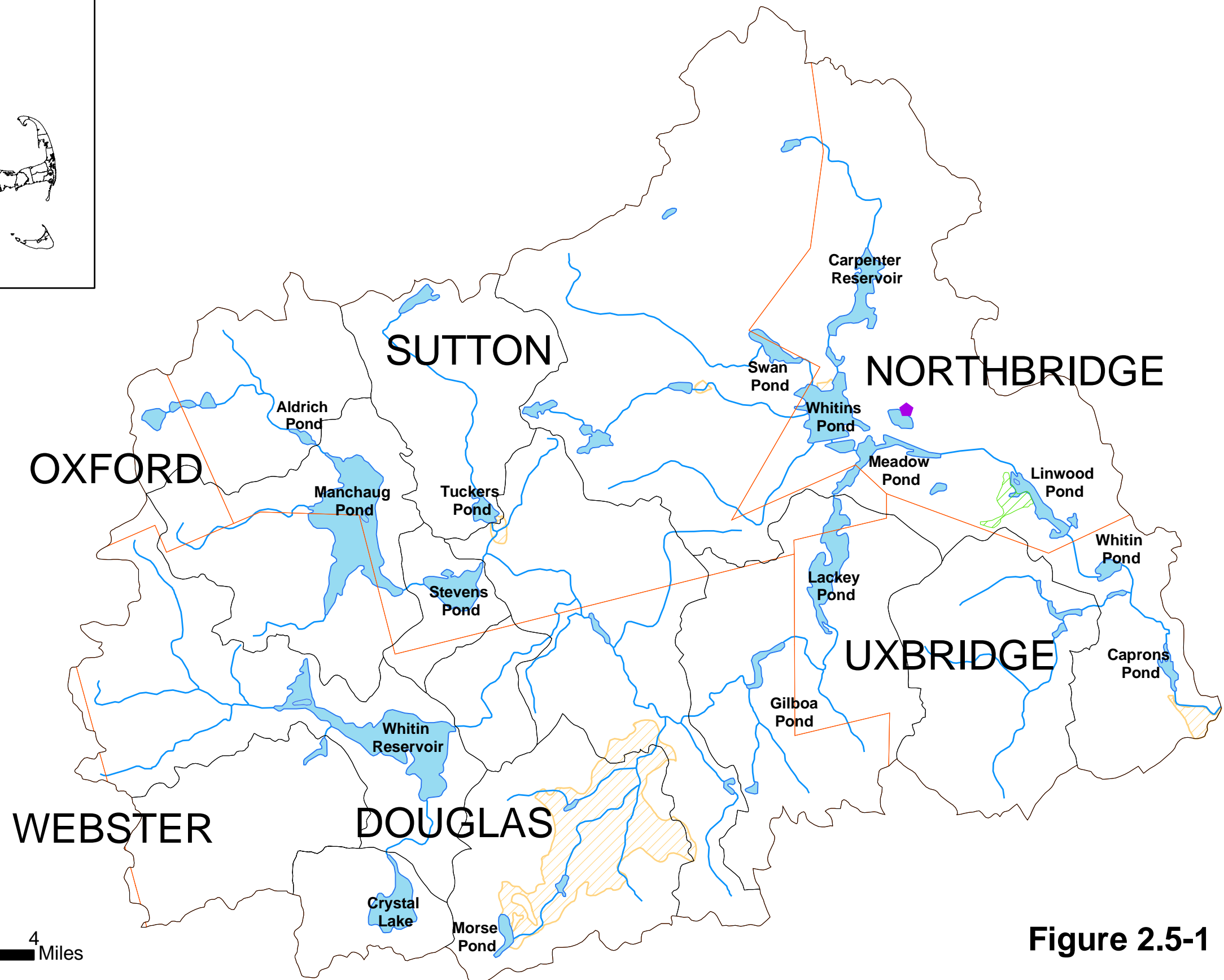


Figure 2.5-1

Average Annual Precipitation (1931-2002), Averages based on Annual Precipitation at the Whitinsville and Uxbridge Precipitation Gages

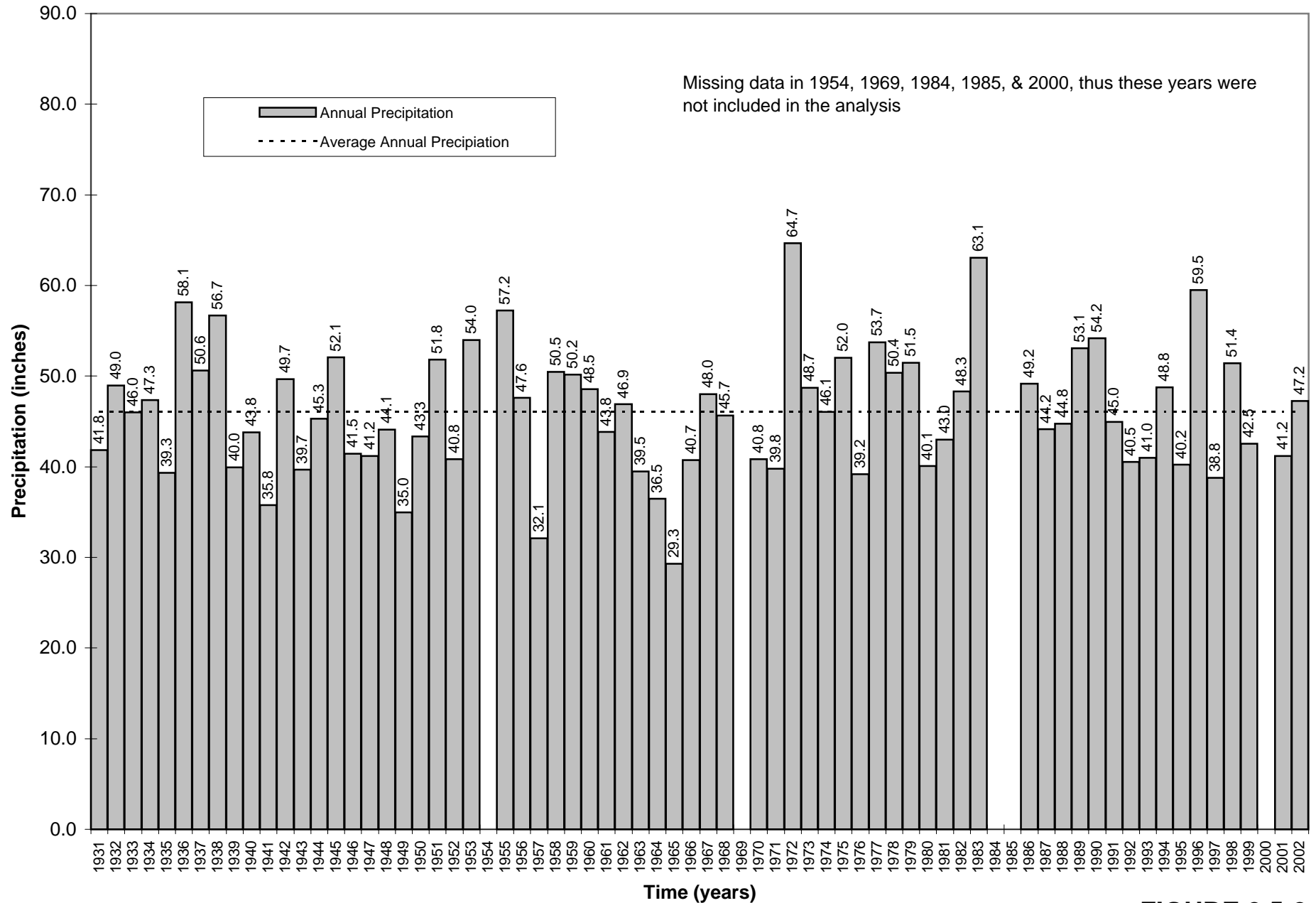
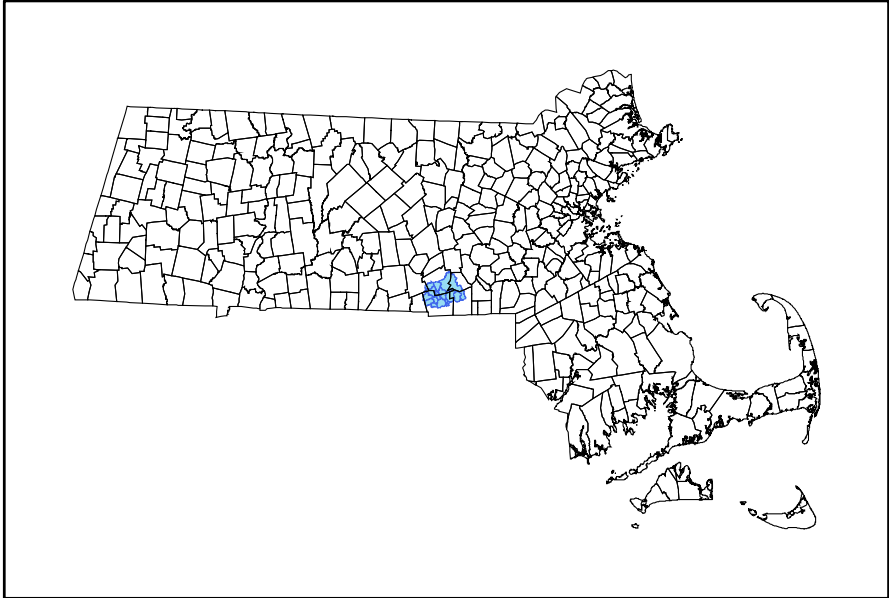


FIGURE 2.5-2

Dams Located in the Mumford River Watershed



Legend

- Dams
- Town Boundaries
- East Douglas WWTP (NPDES Discharge)
- Interface Fabrics Finishing (NPDES Discharge)
- Interface Fabrics Finishing
- Whitinsville Water Company-(Cook Allen Brook Tubular Wellfield)
- Whitinsville Water Company-(Gravel Packed Wellfield)
- Whitinsville Water Company-(Meadow Pond)
- Whitinsville Water Company-(Meadow Pond Tubular Well Field)
- Douglas Water Company-(Glenn St. Well #1)
- Douglas Water Company-(Glenn St. Well #2)
- Douglas Water Company-(West St. Gravel Packed Well)
- Douglas Water Company-(West St. Tubular Wellfield)
- Major Lakes and Ponds
- Major Rivers and Streams
- Watershed Boundary

N

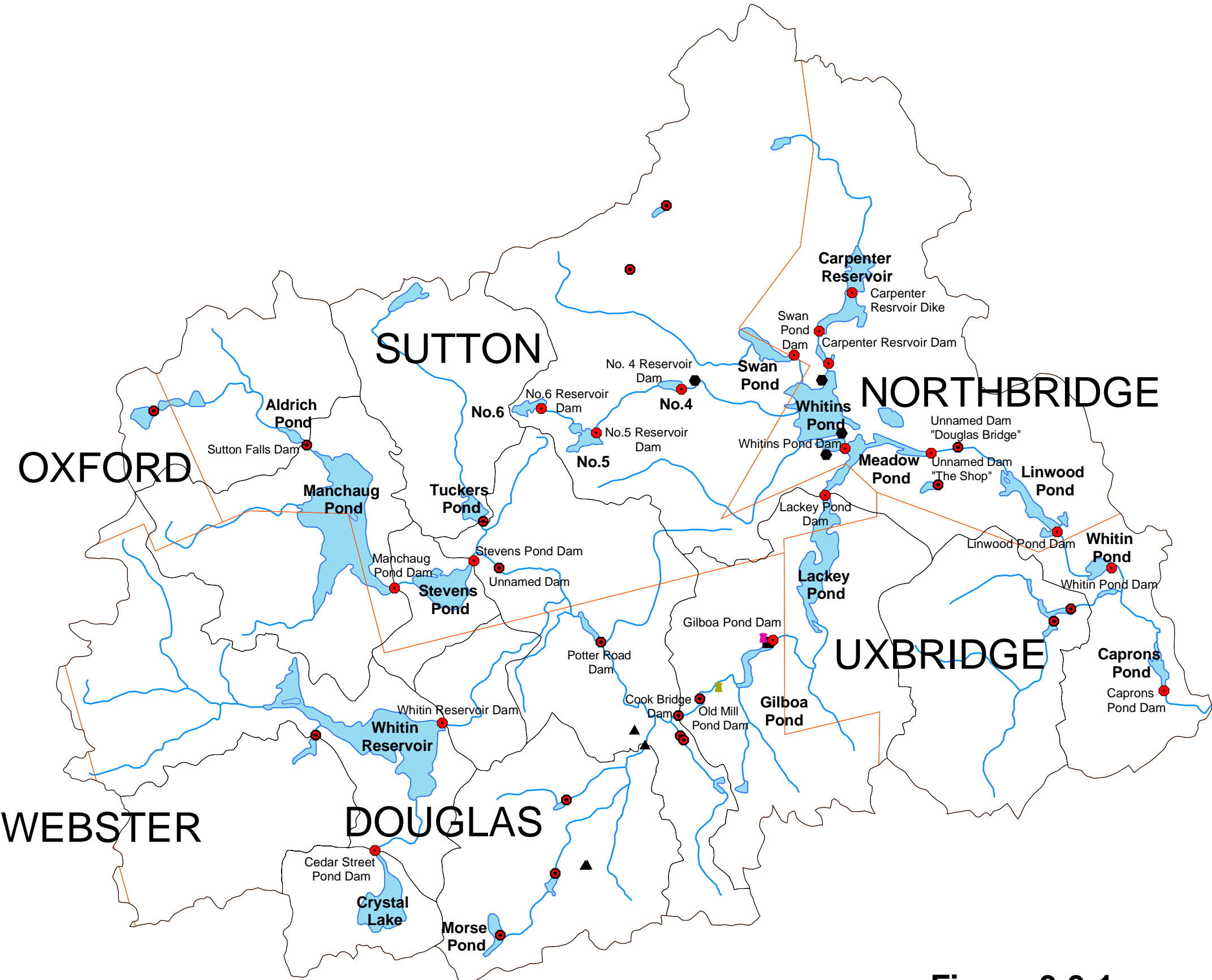
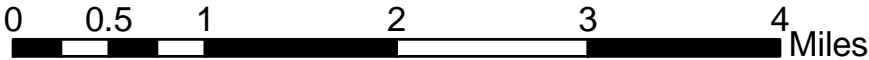
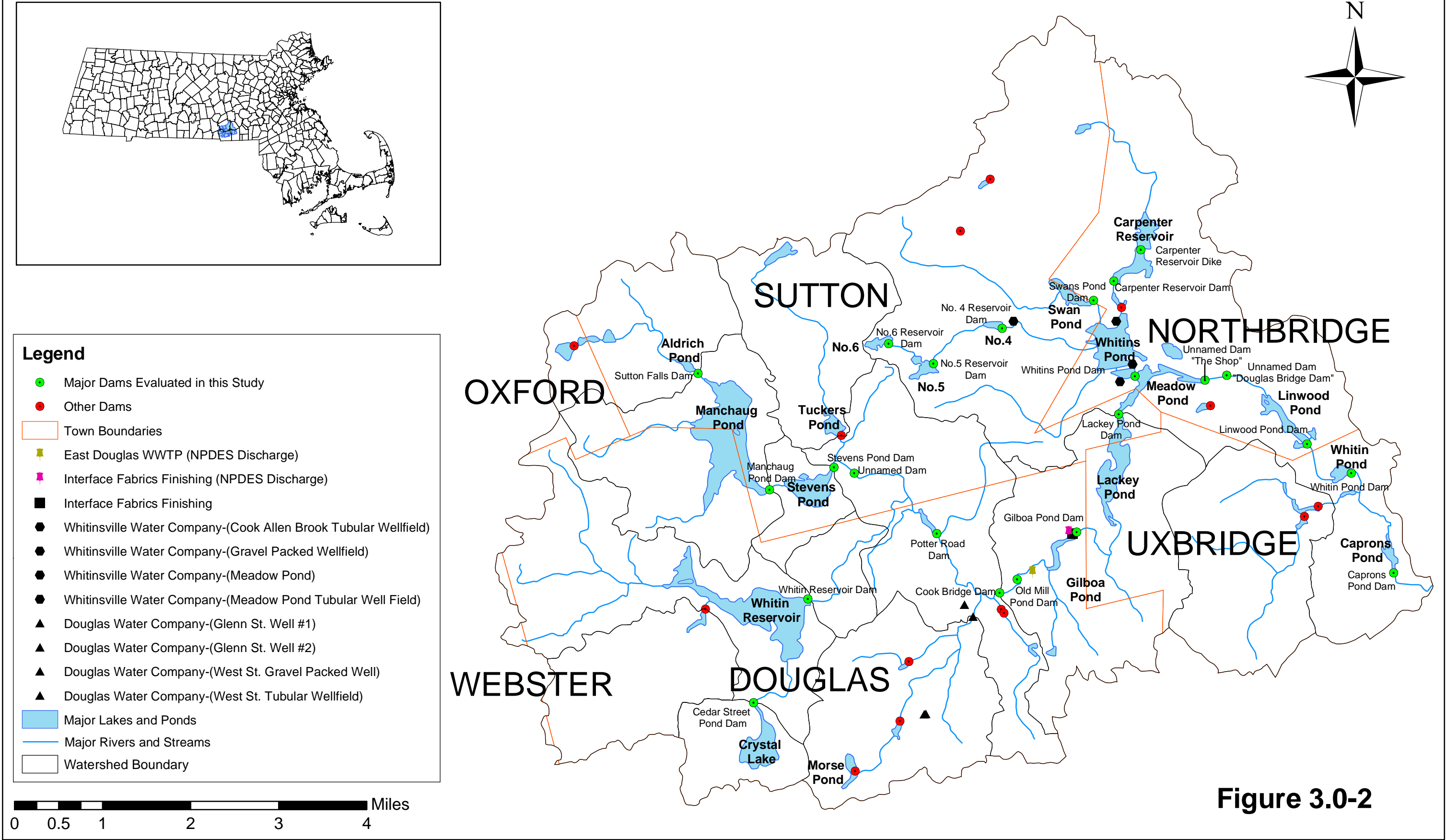


Figure 3.0-1

"Major" Dams in the Mumford River Watershed Evaluated in this Study



Manchaug Pond, Instantaneous Reservoir Elevations for Calendar Years 1999-2002

Data provided by Interface Fabrics Group Finishing, Inc.

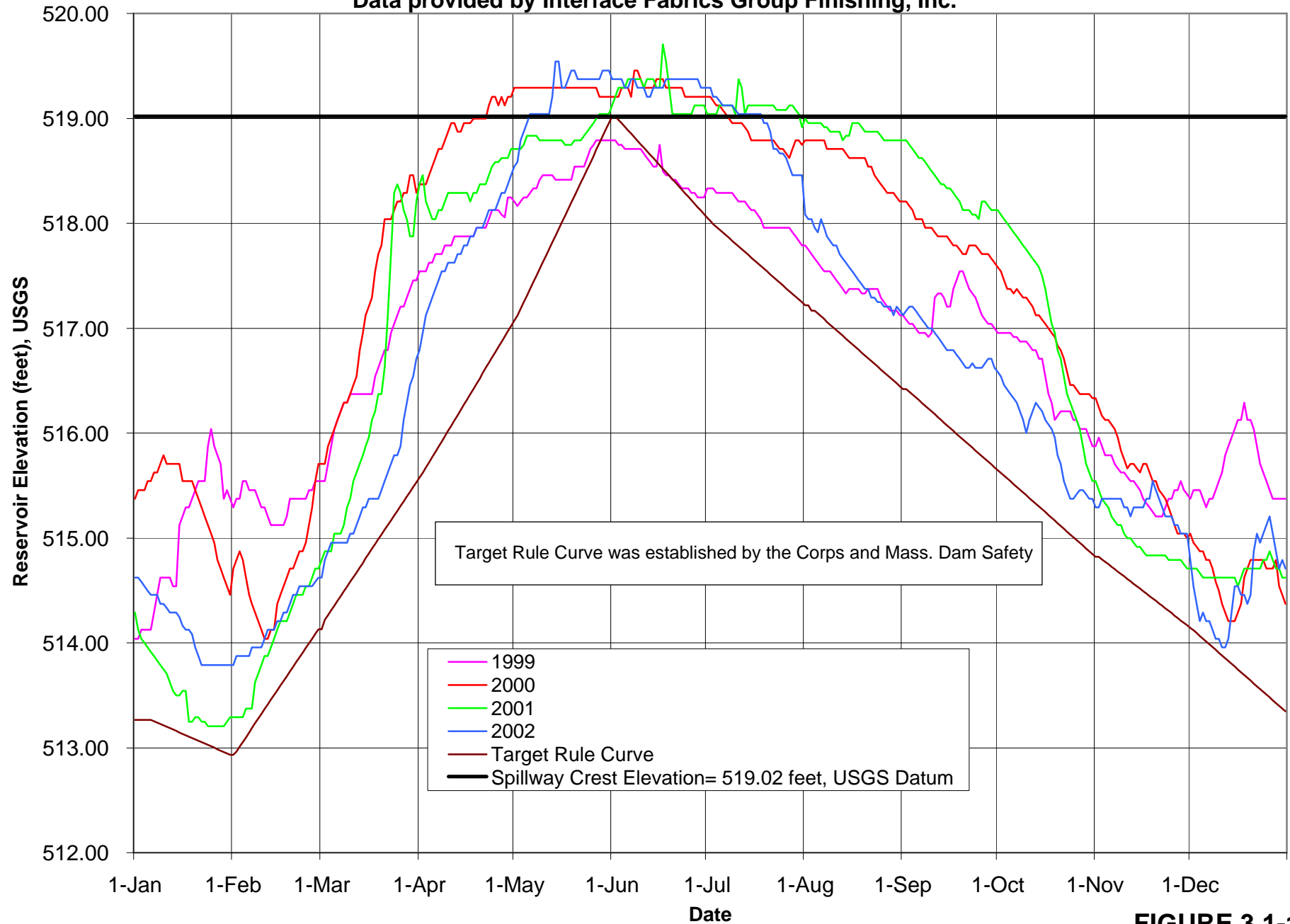


FIGURE 3.1-1

Whitin Reservoir, Instantaneous Reservoir Elevations for Calendar Years 1999-2002
Data provided by Interface Fabrics Group Finishing, Inc.

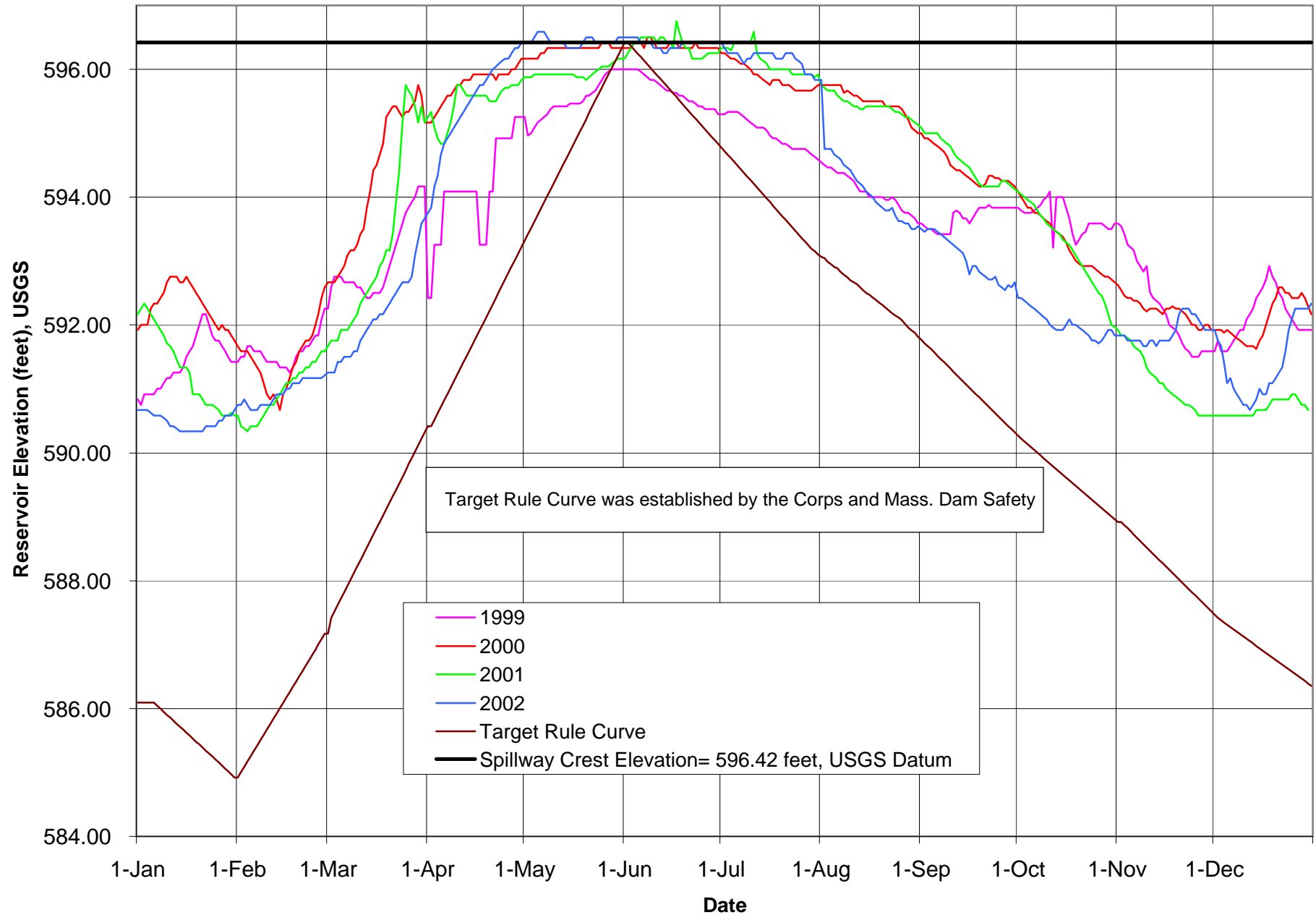


FIGURE 3.1-2

Instantaneous Daily Flow Readings on the Mumford River below Gilboa Dam from 1999-2002

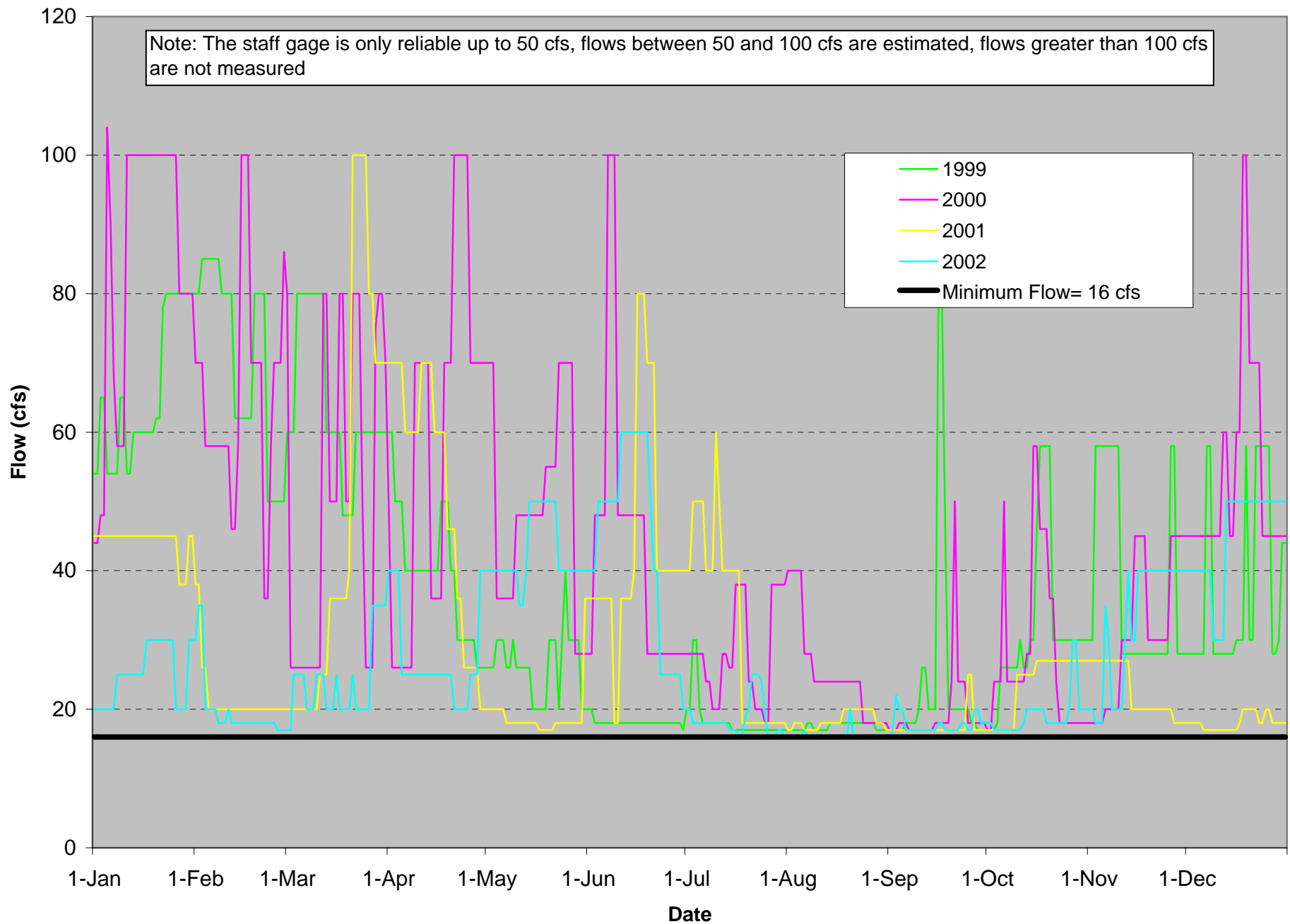


FIGURE 3.1-3

Manchaug Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF Staff Gage in East Douglas, Calendar Year 1999

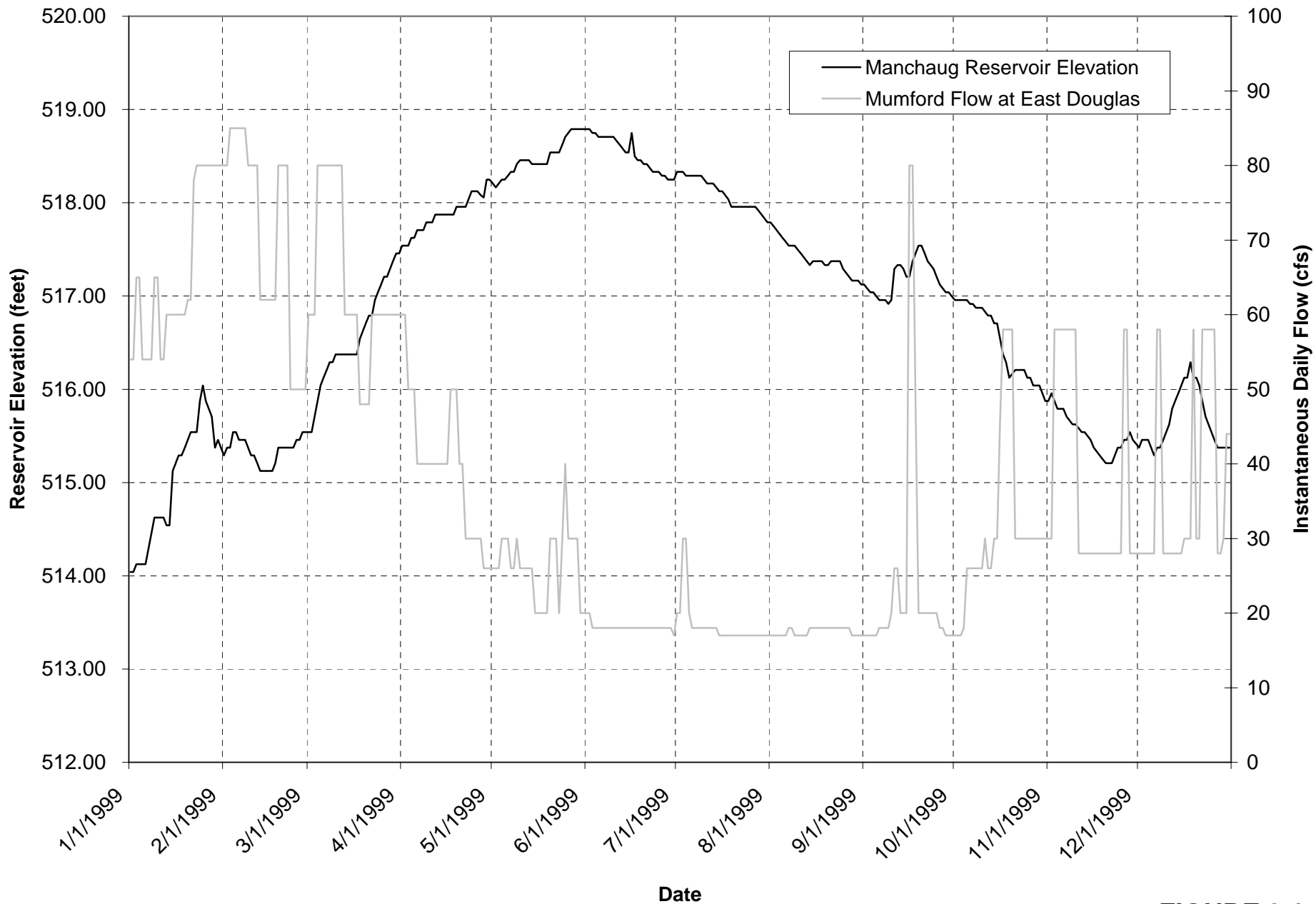


FIGURE 3.1-4

Manchaug Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF Staff Gage in East Douglas, Calendar Year 2000

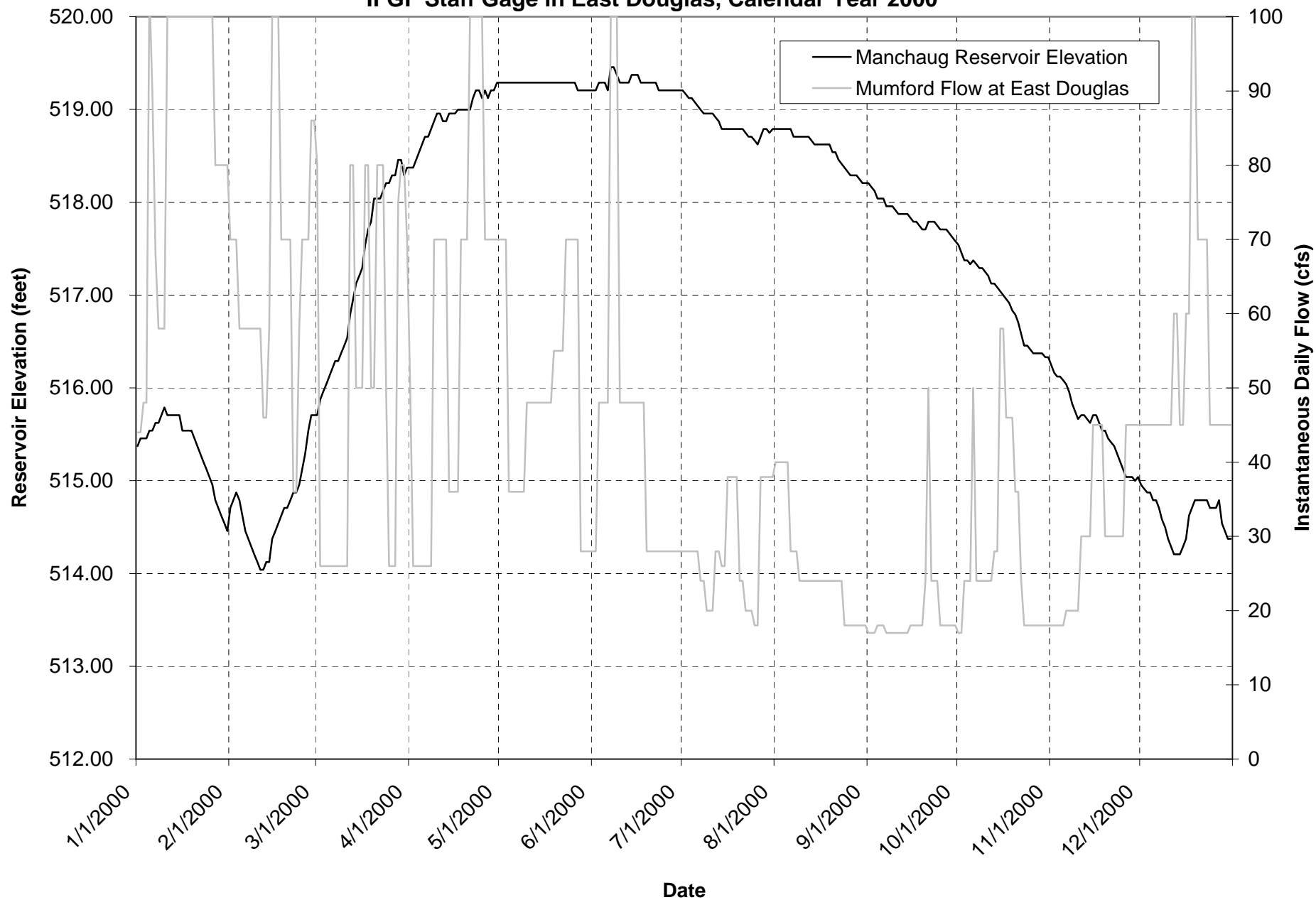


FIGURE 3.1-5

Manchaug Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF Staff Gage in East Douglas, Calendar Year 2001

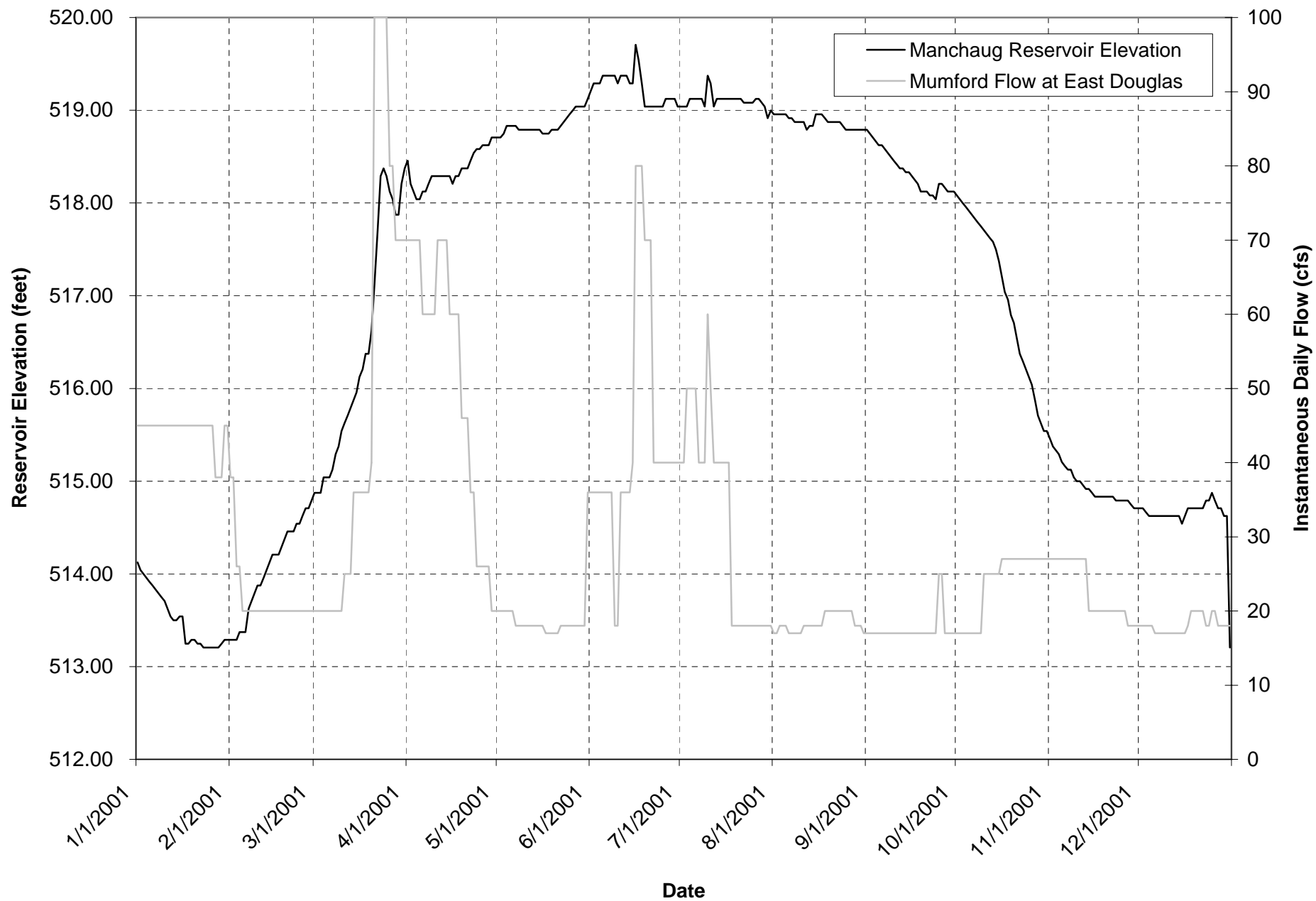


FIGURE 3.1-6

Manchaug Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF Staff Gage in East Douglas, Calendar Year 2002

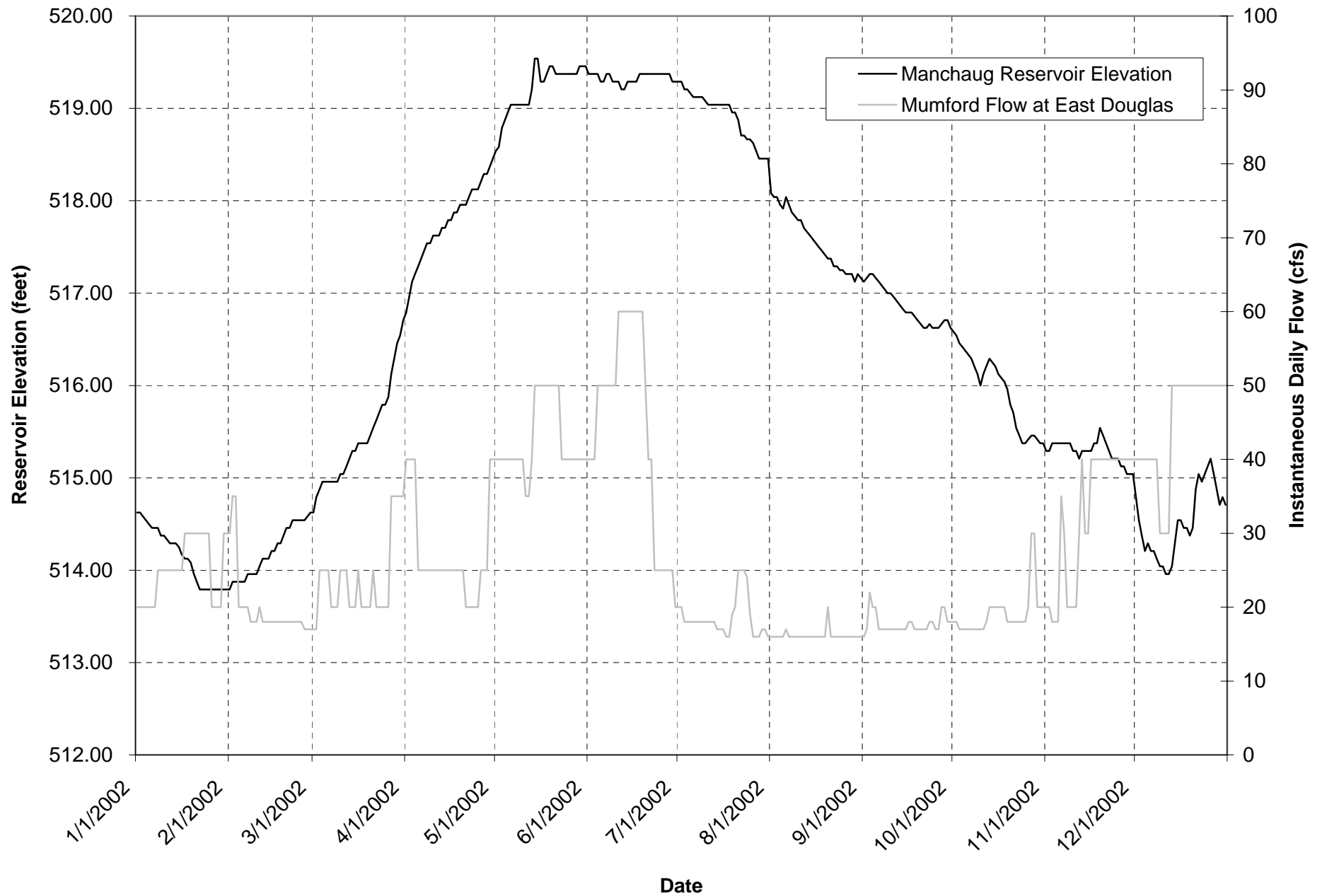


FIGURE 3.1-7

**Whitin Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF
Staff Gage in East Douglas, Calendar Year 1999**

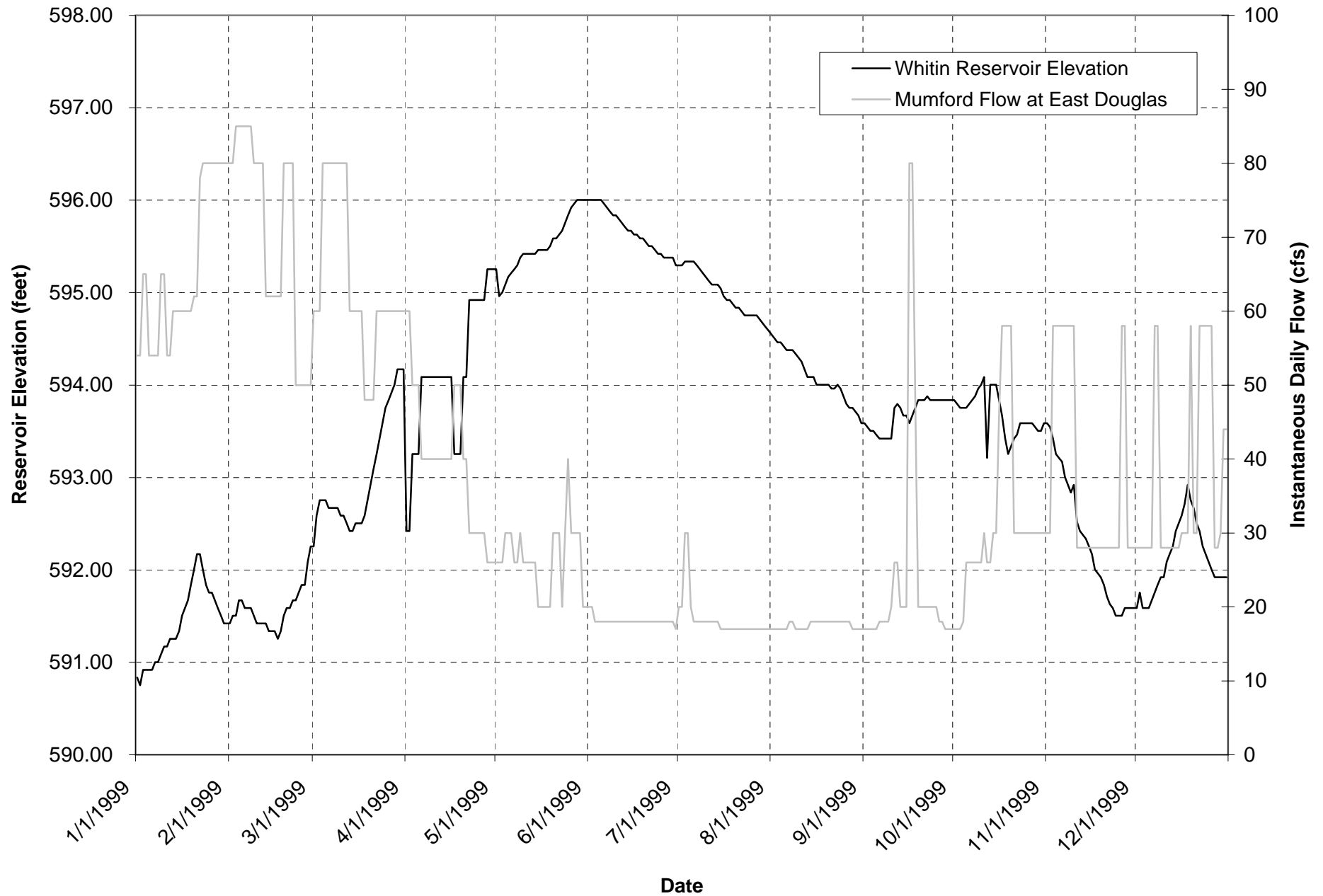


FIGURE 3.1-8

**Whitin Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF
Staff Gage in East Douglas, Calendar Year 2000**

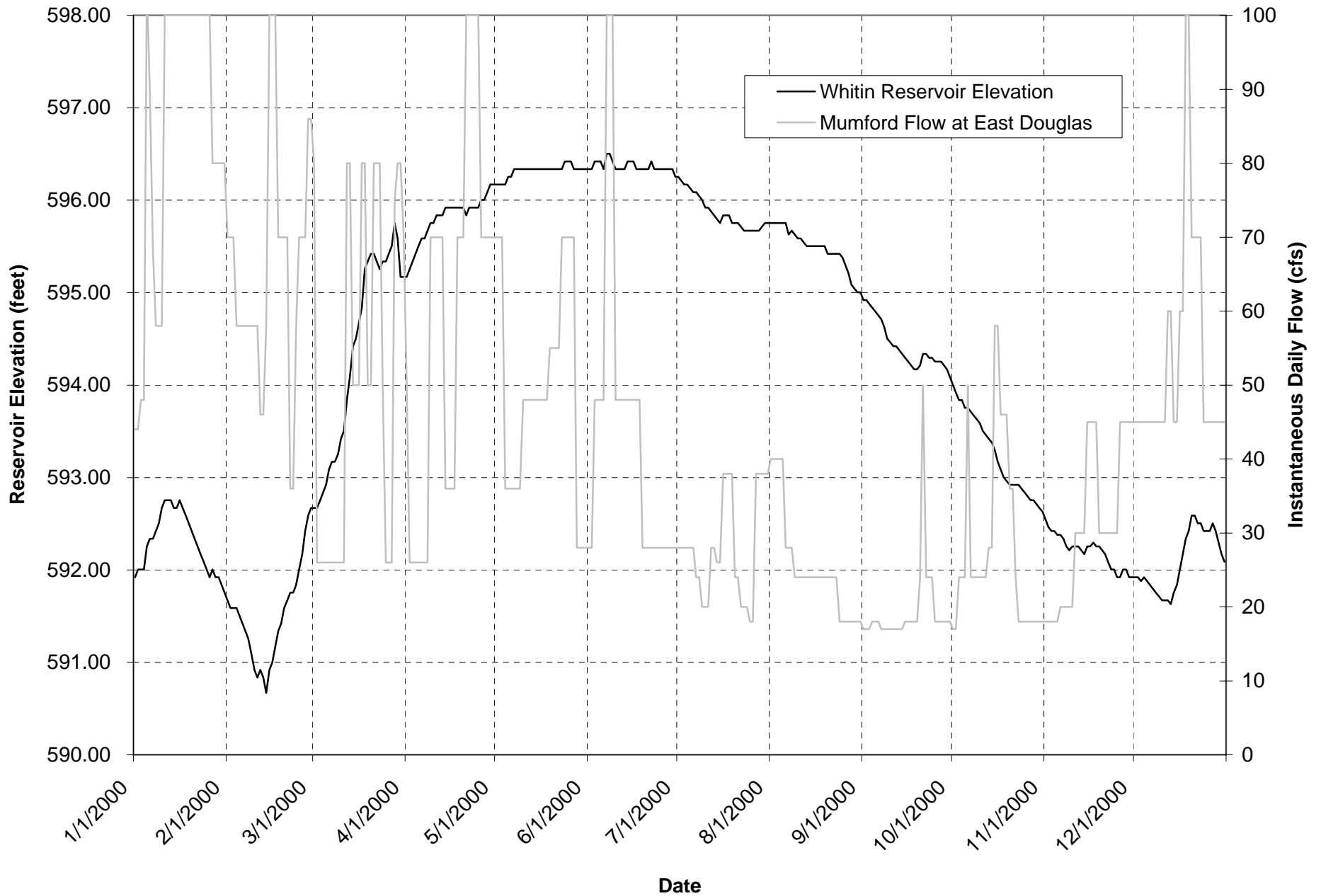


FIGURE 3.1-9

**Whitin Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF
Staff Gage in East Douglas, Calendar Year 2001**

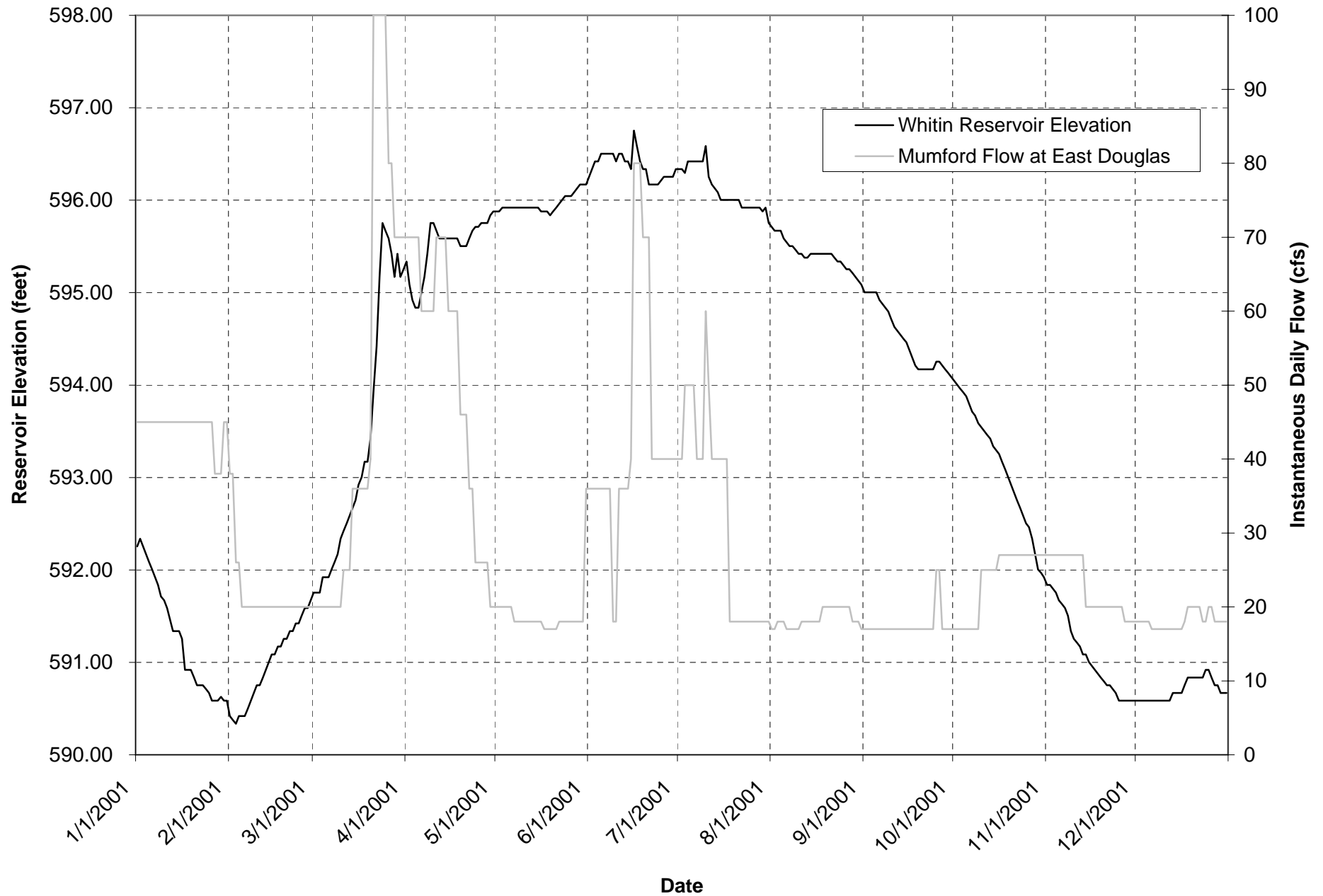


FIGURE 3.1-10

**Whitin Reservoir Elevations and Instantaneous Flow Readings on the Mumford River at the IFGF
Staff Gage in East Douglas, Calendar Year 2002**

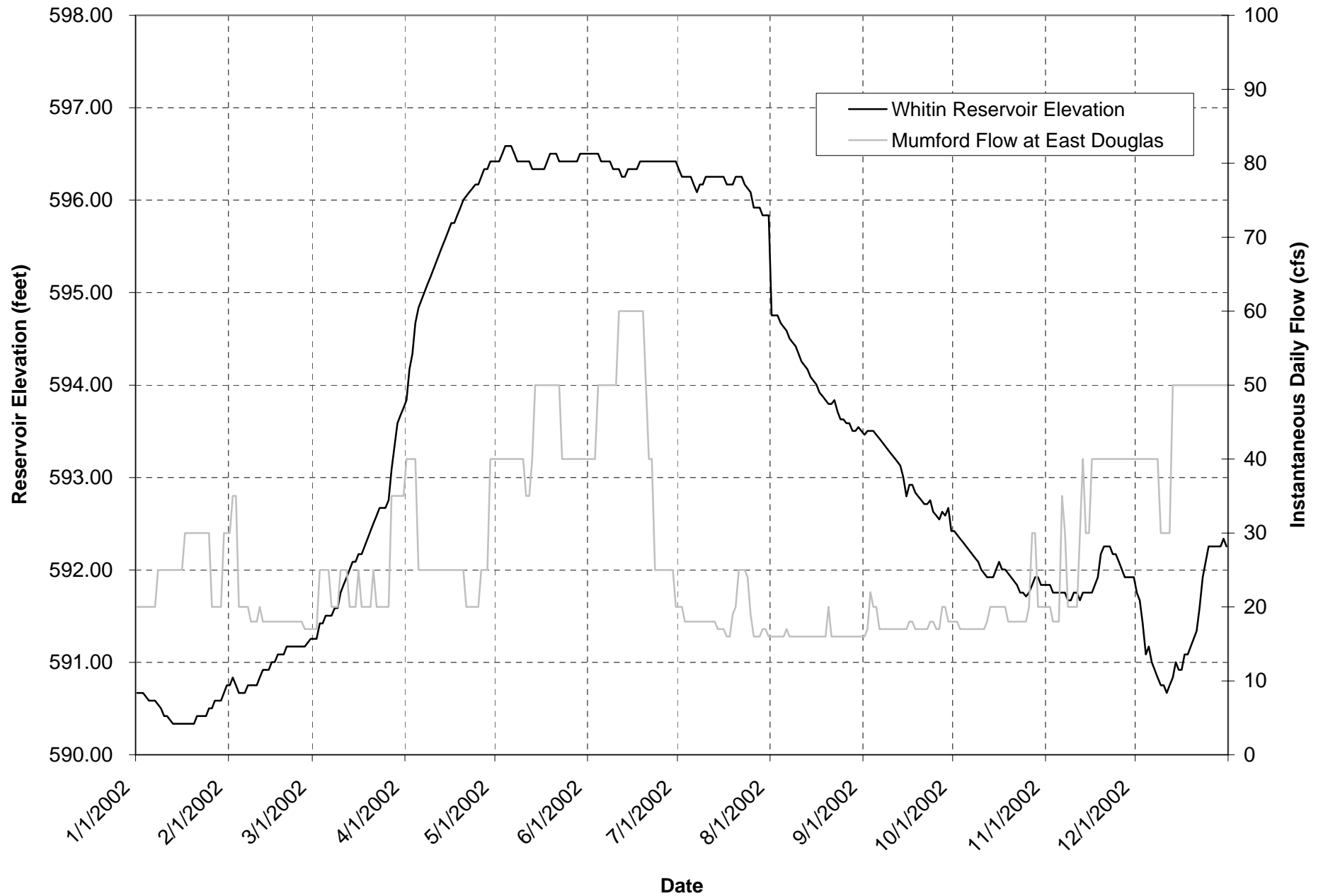


FIGURE 3.1-11

**Scatter Plot of Reservoir No. 6 Water Elevations (relative to full pond) for Calendar Year 2002
(Data Provided by Whitinsville Water Company)**

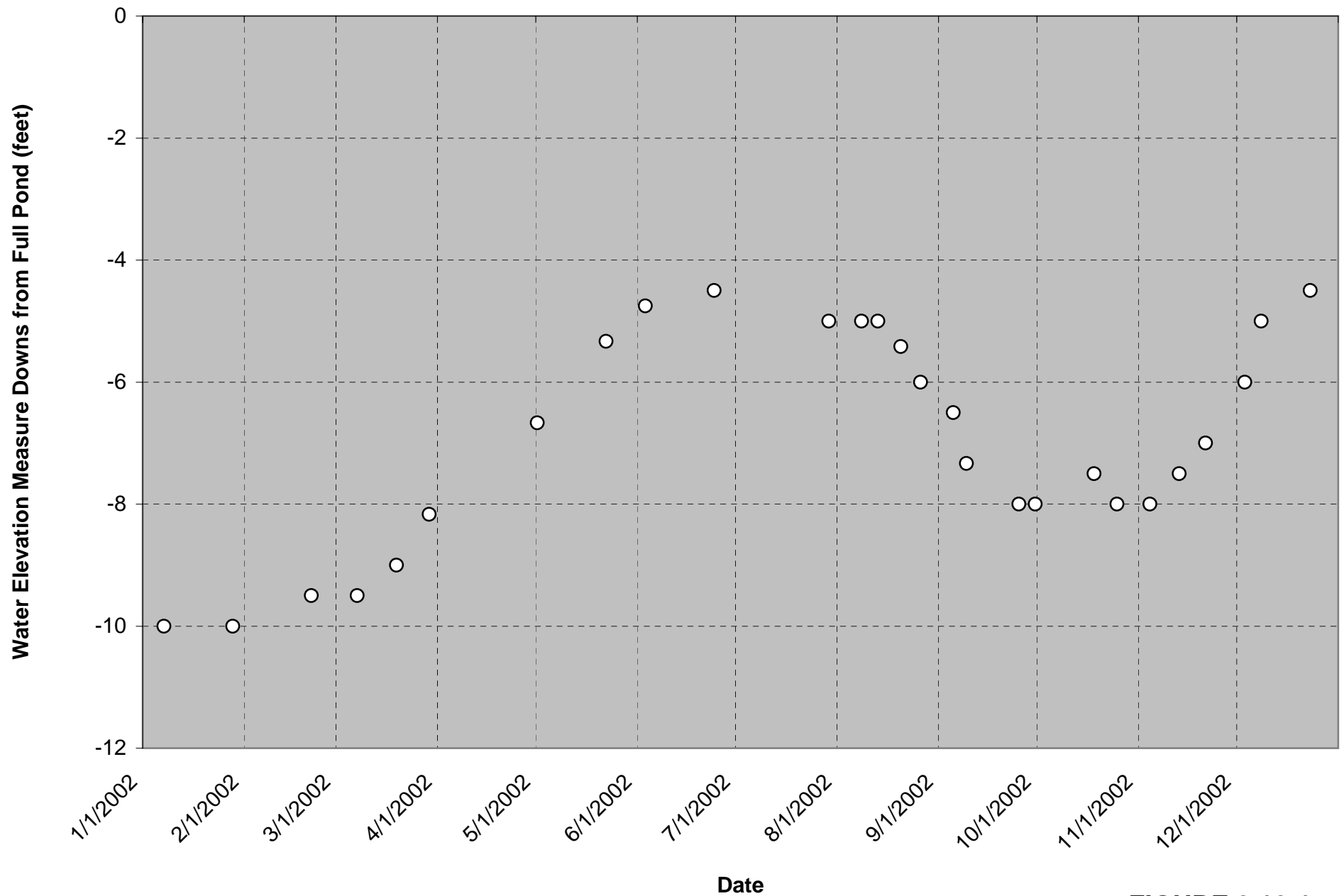


FIGURE 3.10-1

Scatter Plot of Reservoir No. 5 Water Elevations (relative to full pond) for Calendar Year 2002
(Data Provided by Whitinsville Water Company)

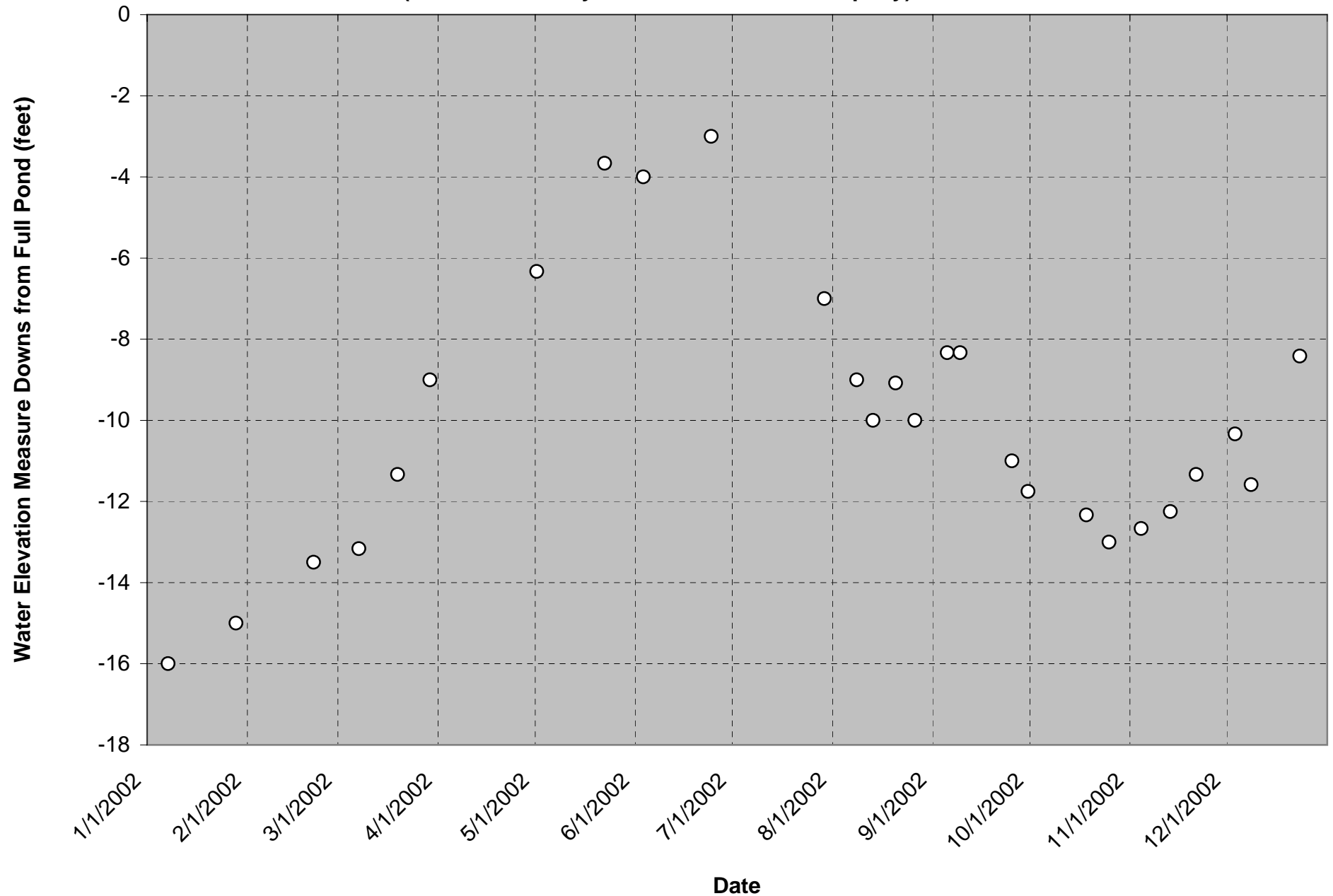


FIGURE 3.10-2

**Scatter Plot of Reservoir No. 4 Water Elevations (relative to full pond) for Calendar Year 2002
(Data Provided by Whitinsville Water Company)**

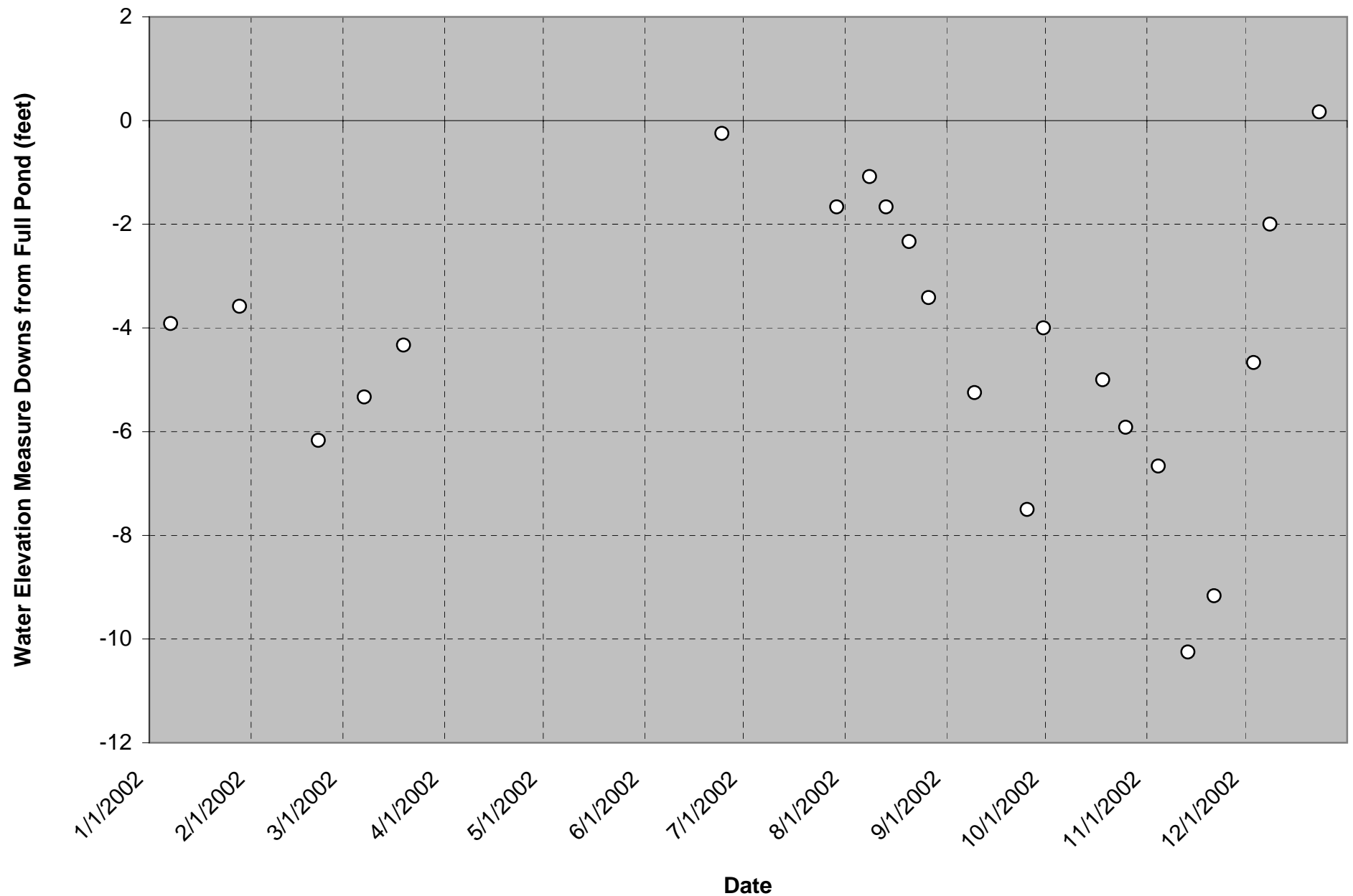


FIGURE 3.10-3

Reservoir No. 6- Stage versus Storage Curve (Source: Whitinsville Water Company)

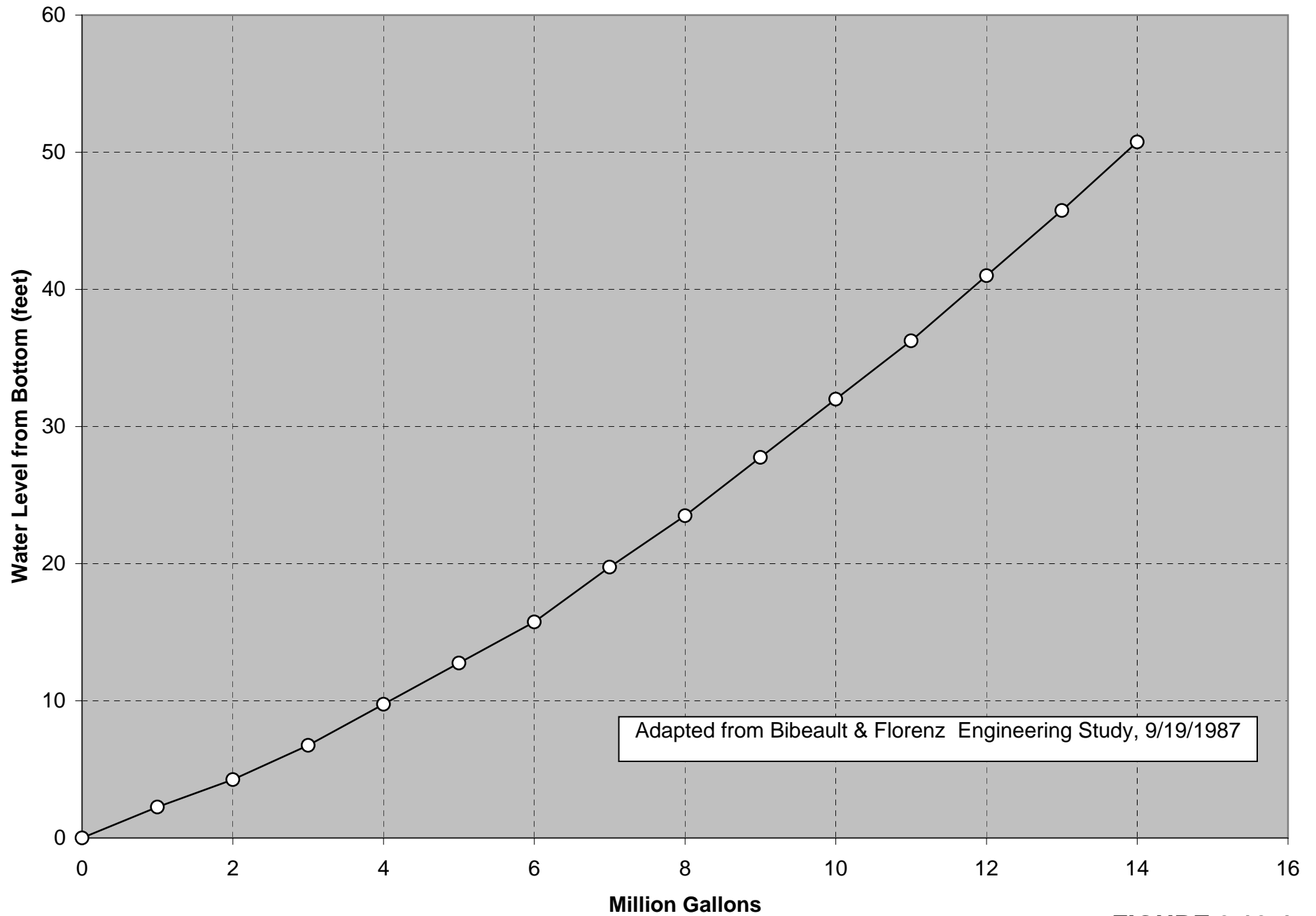


FIGURE 3.10-4

Reservoir No. 5- Stage versus Storage Curve (Source: Whitinsville Water Company)

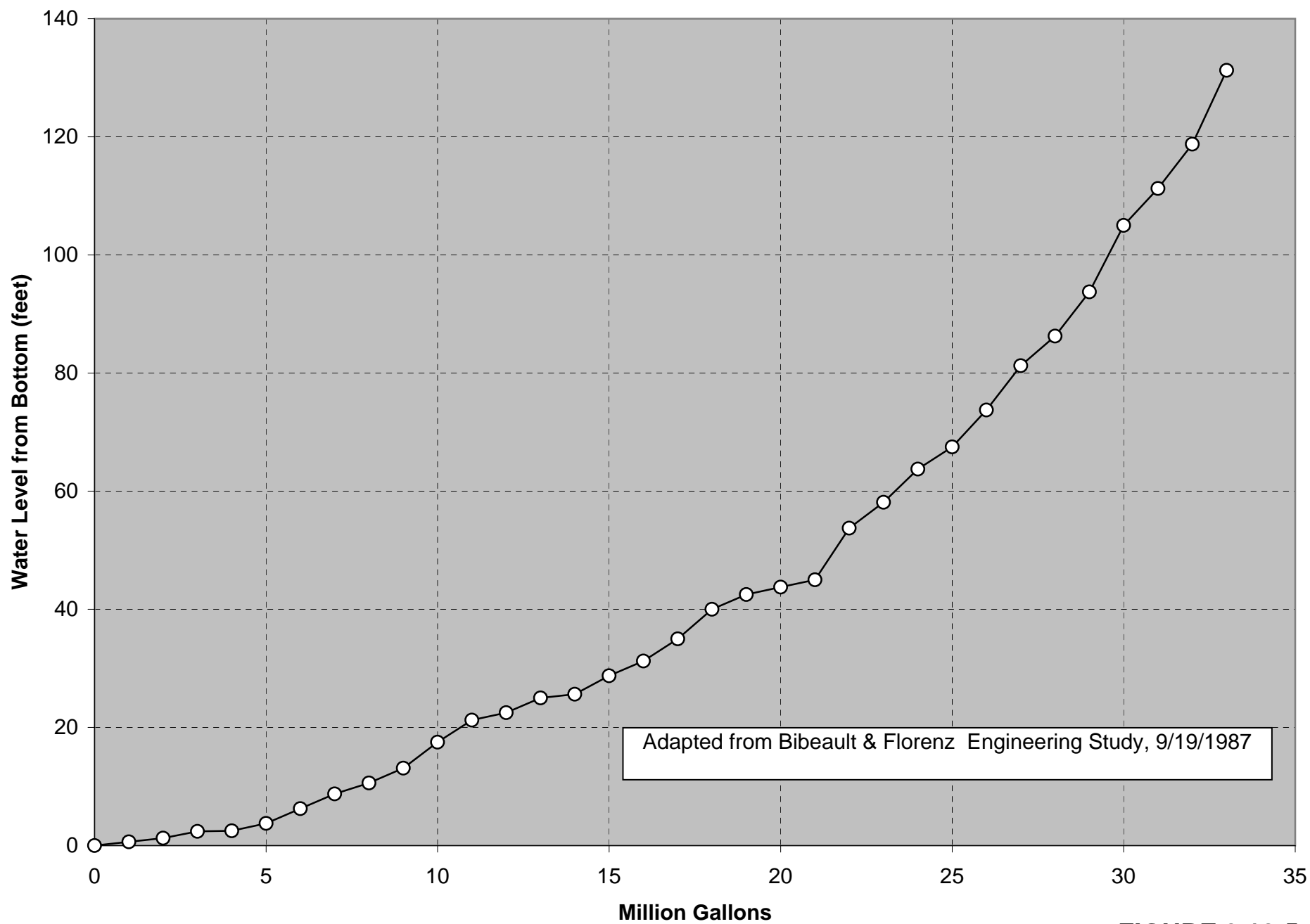
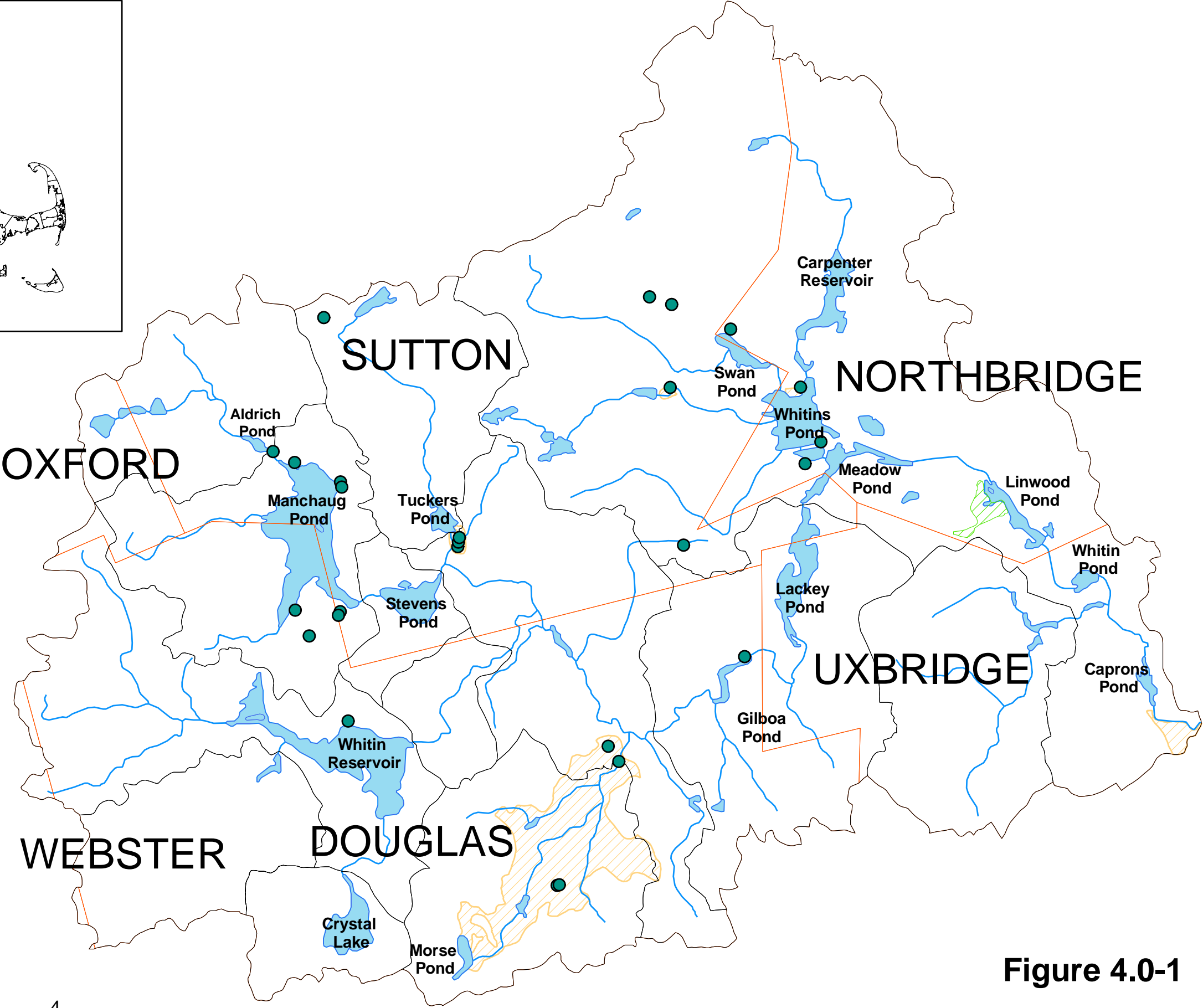
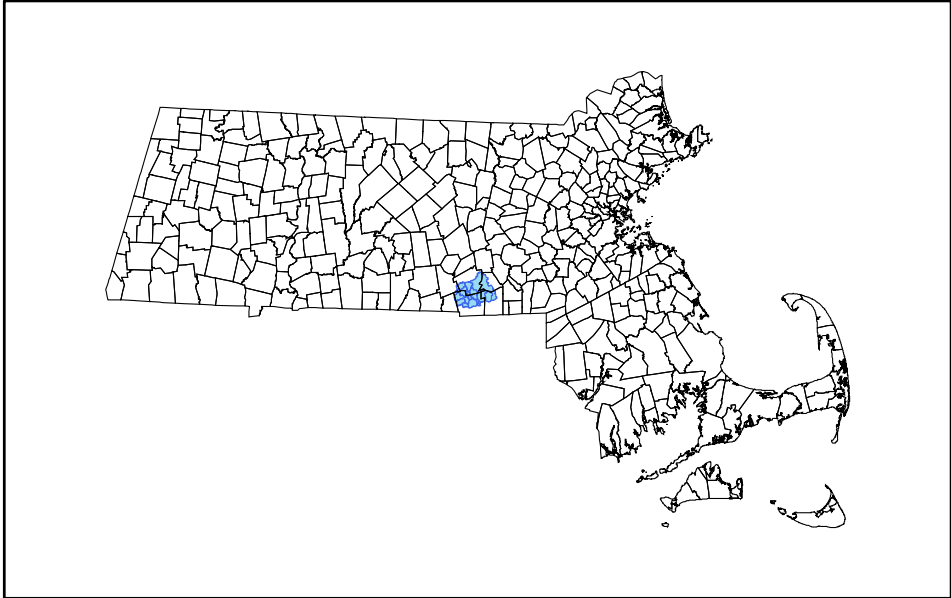


FIGURE 3.10-5

All Water Withdrawals in the Mumford River Watershed

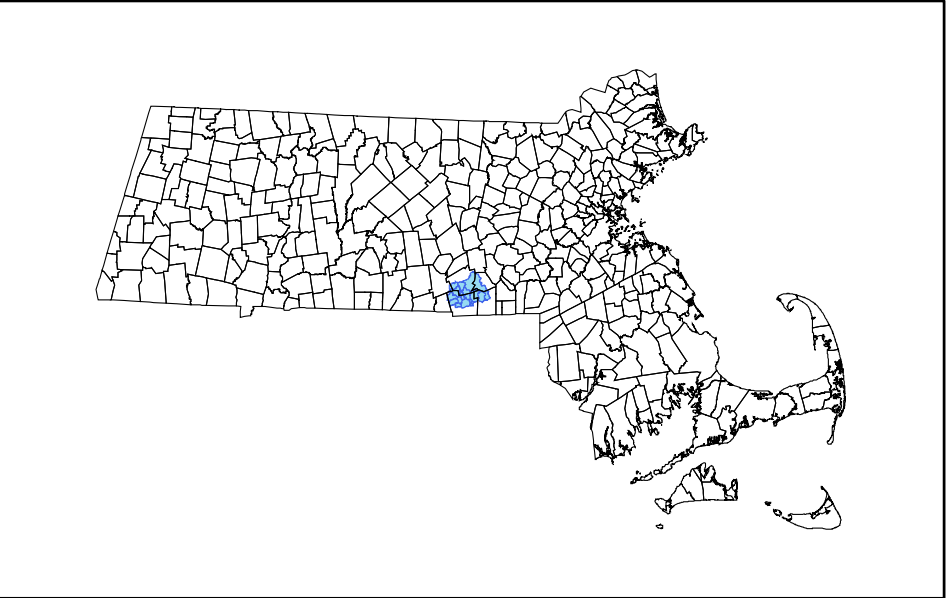


Legend






- Water Withdrawals
- Whitinsville Golf Course
- Zone 2 Wellhead Protection Area
- Watershed Boundary
- Town Boundaries
- Major Lakes and Ponds
- Major Rivers and Streams


Figure 4.0-1

Water Supply Companies Located in the Mumford River Watershed

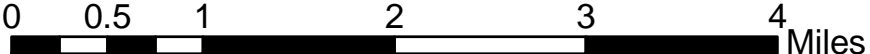


Legend

- Interface Fabrics Finishing
- Whitinsville Water Company-(Cook Allen Brook Tubular Wellfield)
- Whitinsville Water Company-(Gravel Packed Wellfield)
- Whitinsville Water Company-(Meadow Pond)
- Whitinsville Water Company-(Meadow Pond Tubular Well Field)
- ▲ Douglas Water Company-(Glenn St. Well #1)
- ▲ Douglas Water Company-(Glenn St. Well #2)
- ▲ Douglas Water Company-(West St. Gravel Packed Well)
- ▲ Douglas Water Company-(West St. Tubular Wellfield)
-  Whitinsville Golf Course
-  Watershed Boundary
-  Town Boundaries
-  Major Lakes and Ponds
-  Major Rivers and Streams



N



0 0.5 1 2 3 4 Miles

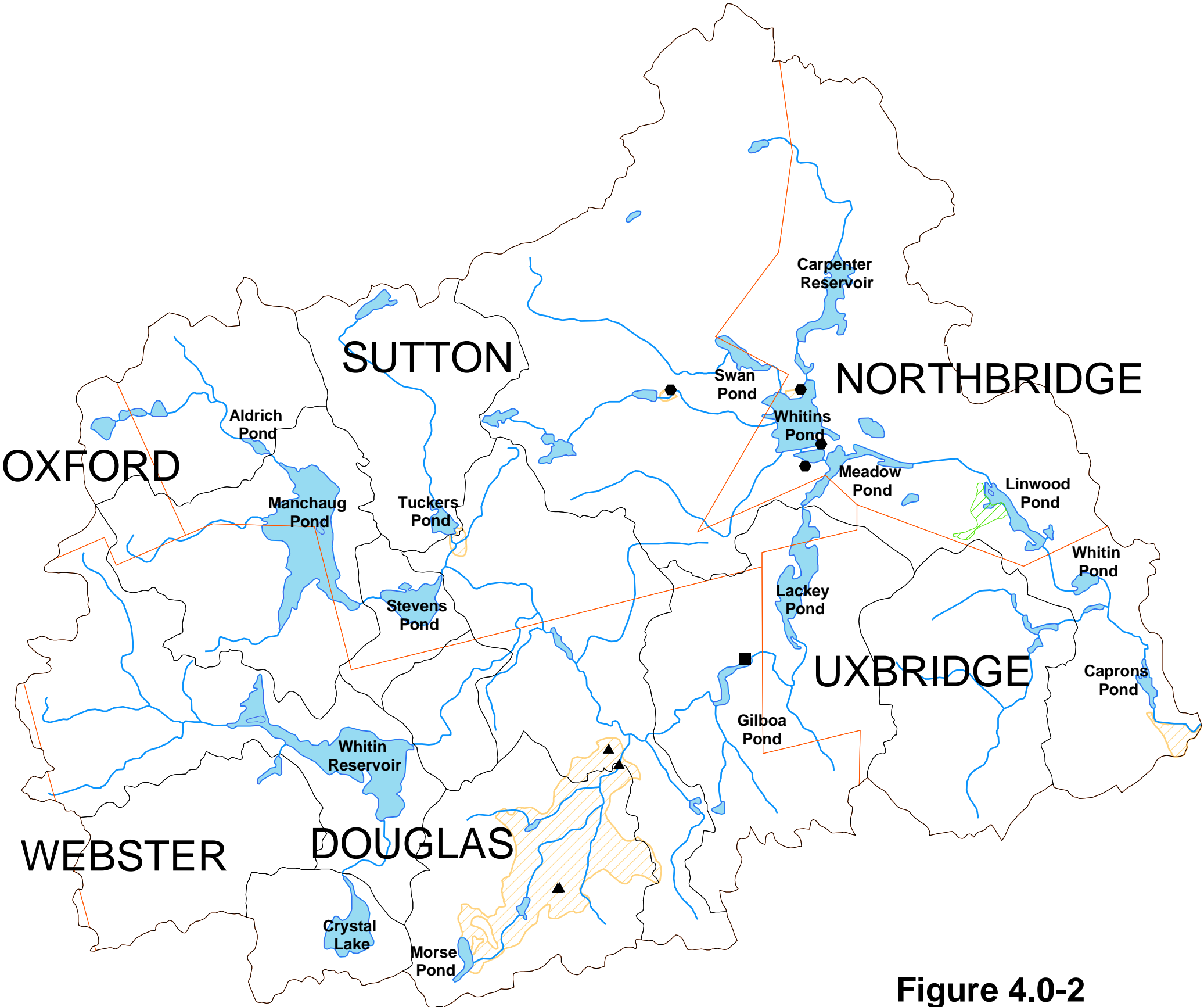


Figure 4.0-2

Whitinsville Water Company: Summary of Annual Water Usage and Sources from 1998-2001

Annual Demand (MGY), Average Daily Demand (MGD), Peak Demand (MGD) and Peak/Average Demand Ratio

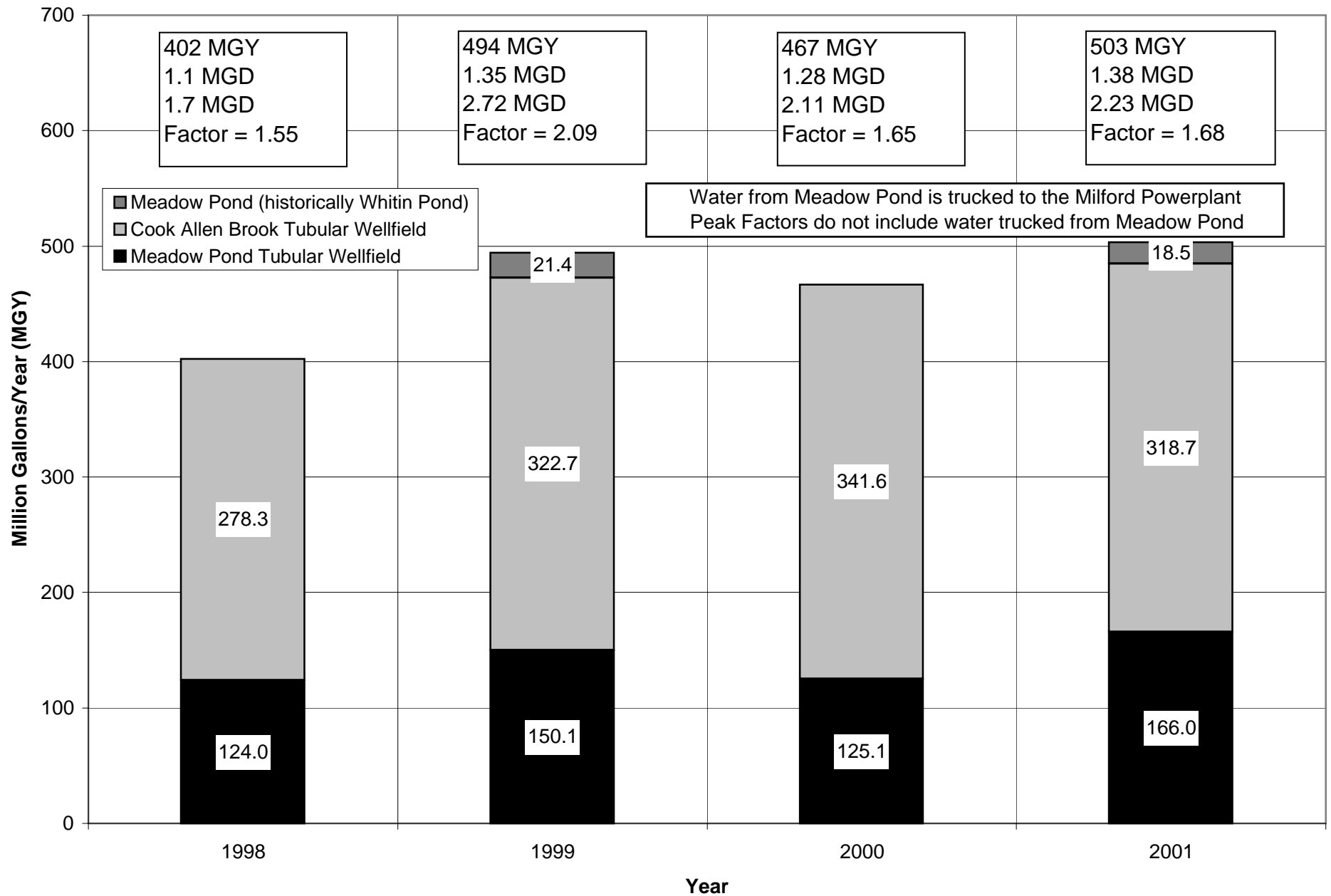


FIGURE 4.1.1-1

Whitinsville Water Company: Summary of Water Sources Used to Meet Demand (including cooling water from Meadow Pond) on a Monthly Basis-Averages Based on Period 1998-2001

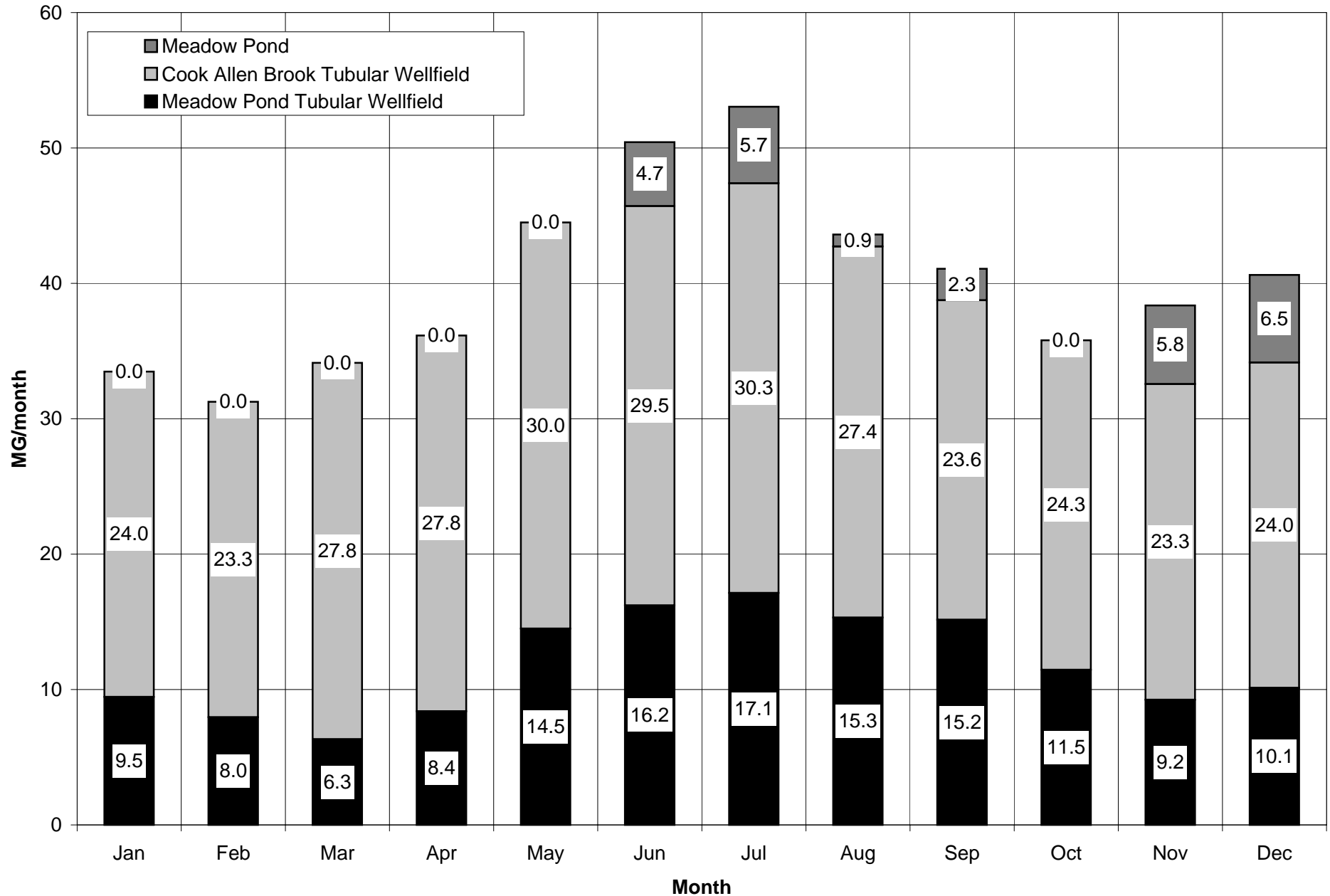


FIGURE 4.1.1-2

**Whitinsville Water Department-Population Served Throughout the Year and Average Gallons per
Capita Day (gpcd)**

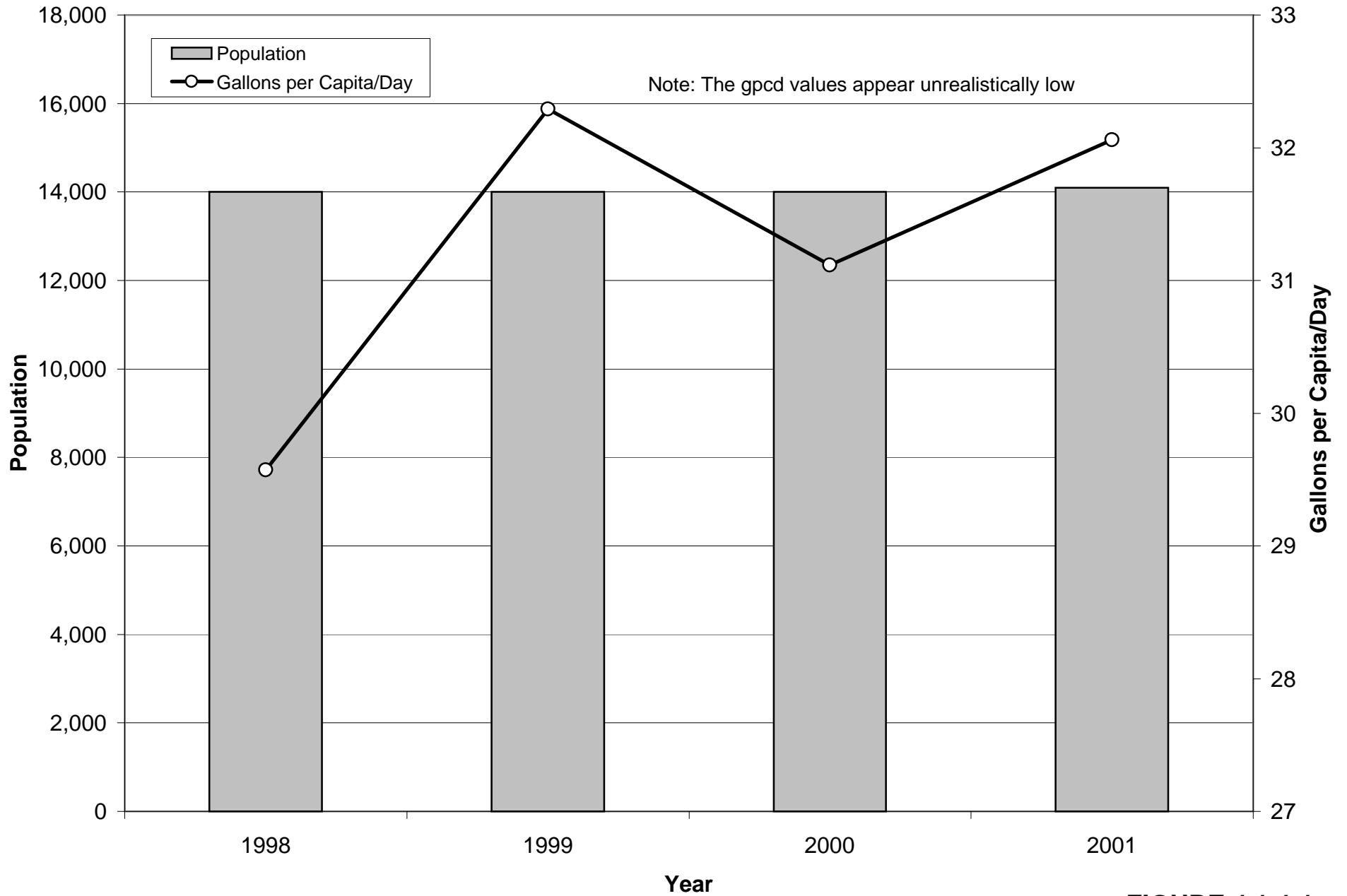


FIGURE 4.1.4-1

Northbridge Water Division-Population Served Throughout the Year and Average Gallons per Capita Day (gpcd)

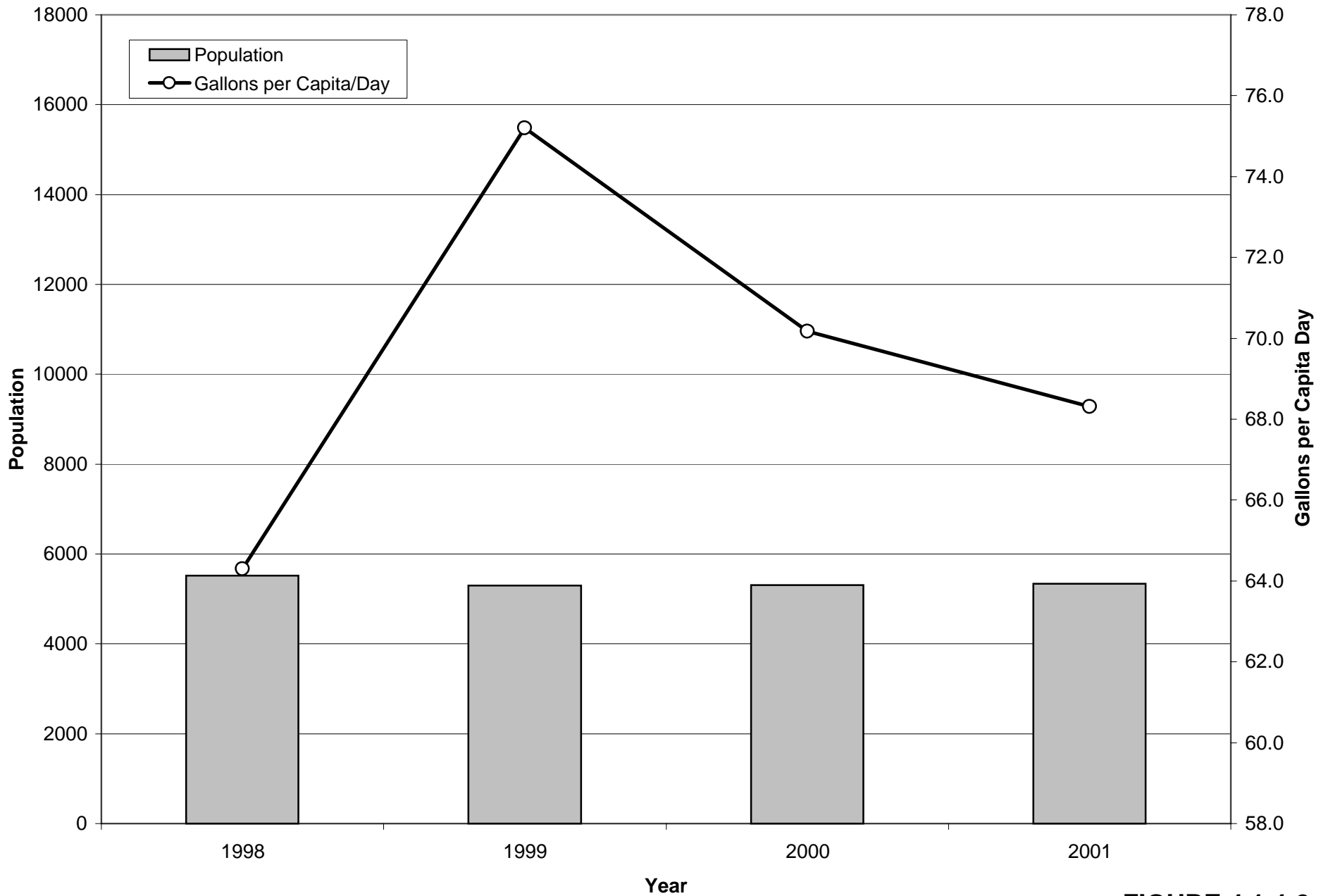


FIGURE 4.1.4-2

Whitinsville and Northbridge - Water Distribution System Relative to the Mumford River Basin

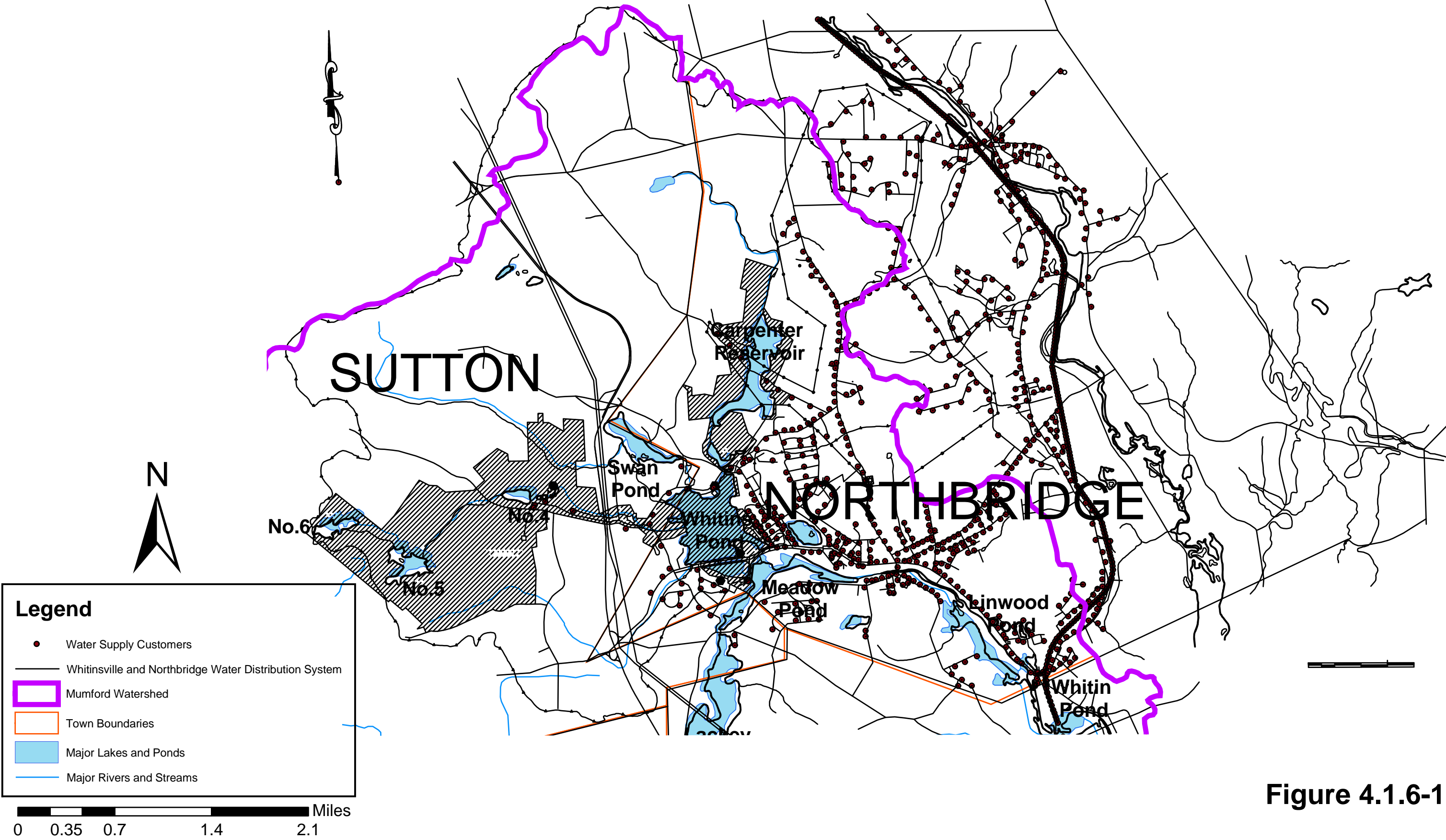


Figure 4.1.6-1

Whitinsville Water Company, Estimated Volume of their Water Supply and Water Sold to Northbridge 1) Sent to the Northbridge WWTP, 2) Lost to Evaporation from outdoor use and 3) Returned to the Mumford River Basin, Averages based on the Period 1998-2001

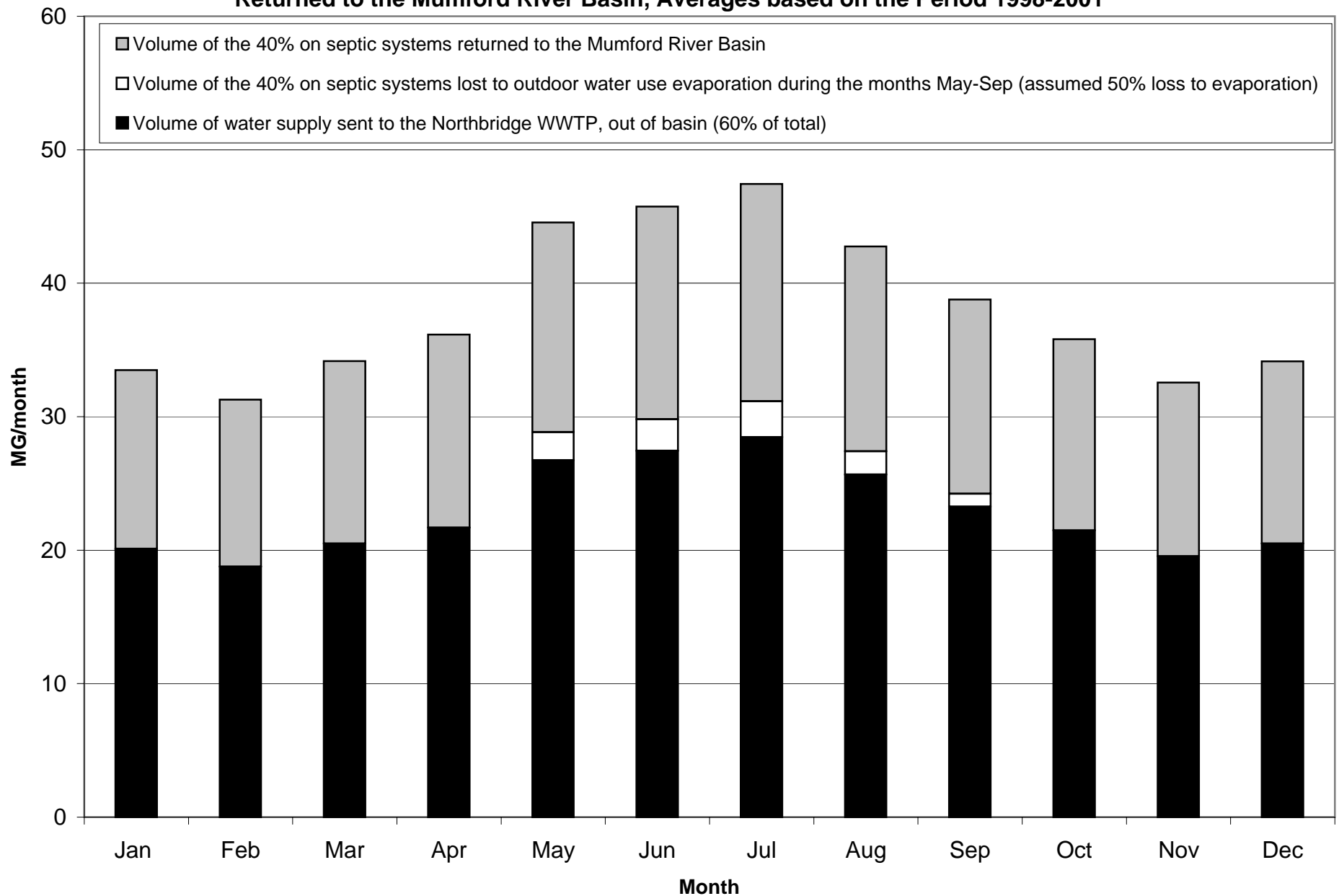


FIGURE 4.1.6-2

Whitinsville Water Company, Estimated Volume of their Water Supply and Water Sold to Northbridge 1) Sent to the Northbridge WWTP, 2) Lost to Evaporation from outdoor use and 3) Returned to the Mumford River Basin, Averages based on the Period 1998-2001

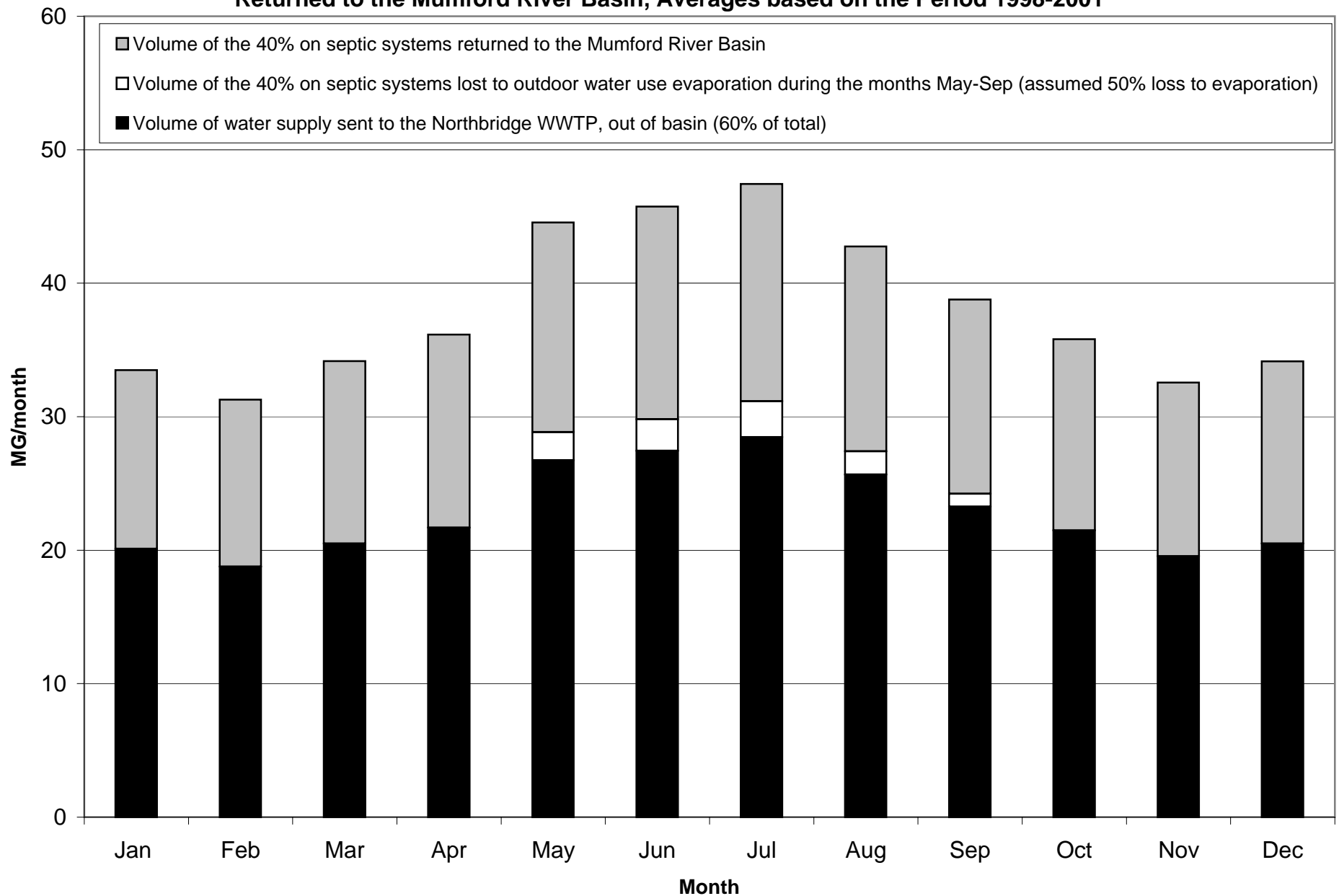


FIGURE 4.1.6-2

Douglas Water Department: Summary of Annual Water Usage and Sources from 1998-2001

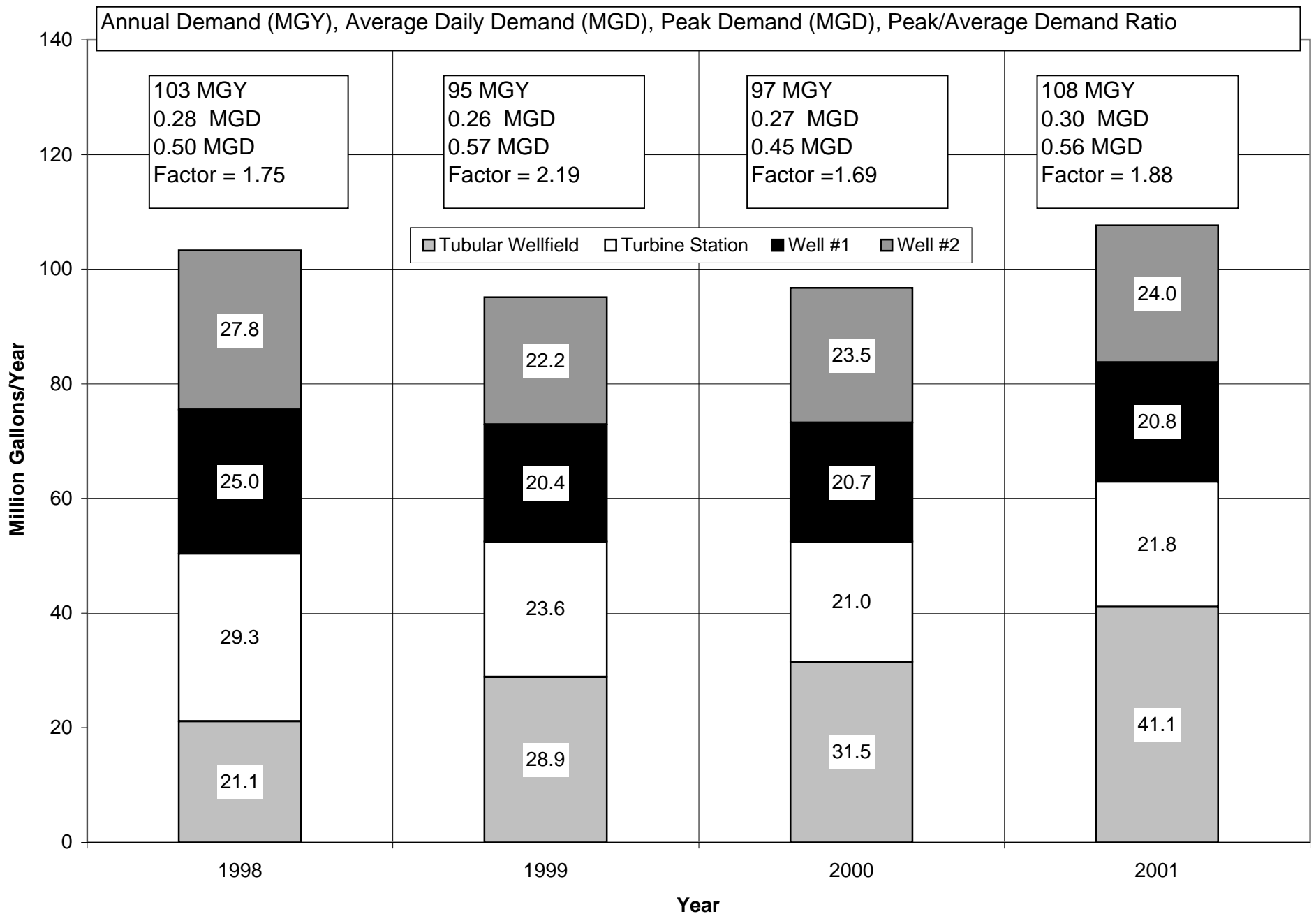


FIGURE 4.2.1-1

**Douglas Water Department: Summary of Water Sources Used to Meet Demand on a Monthly Basis-
Averages Based on Period 1998-2001**

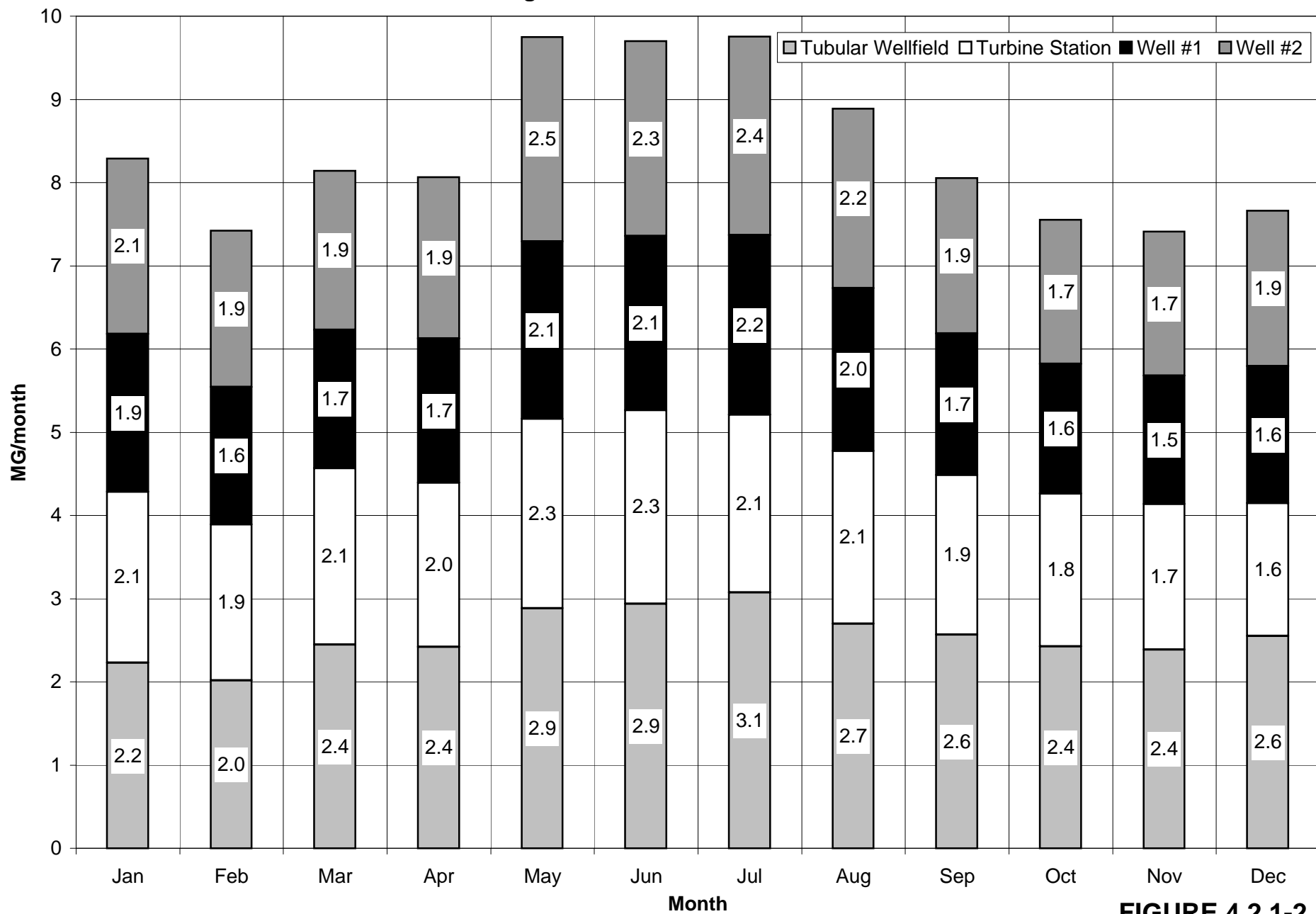


FIGURE 4.2.1-2

Douglas Water Department: Population Served Throughout the Year and Average Daily Gallons per Capita (gpcd)

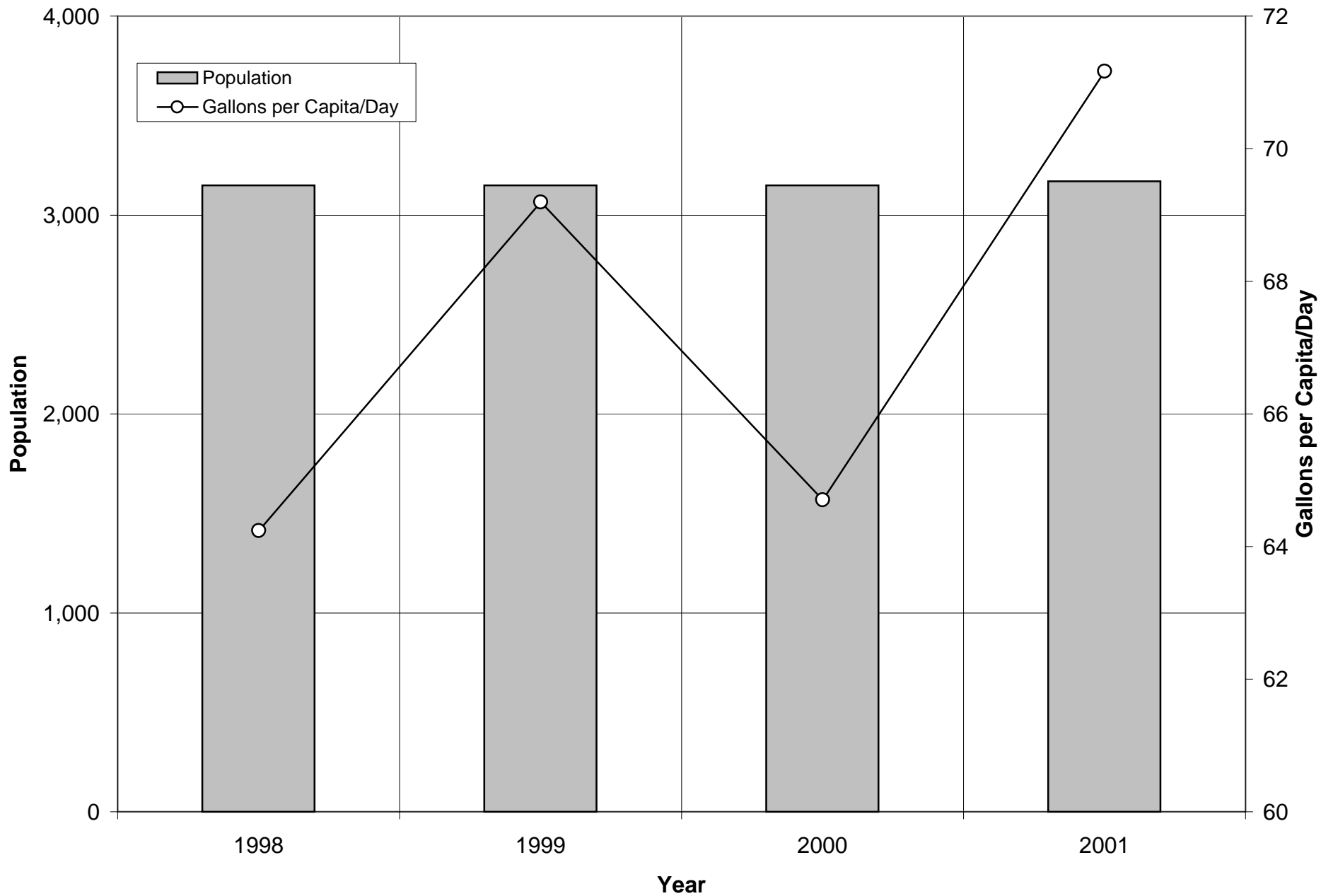
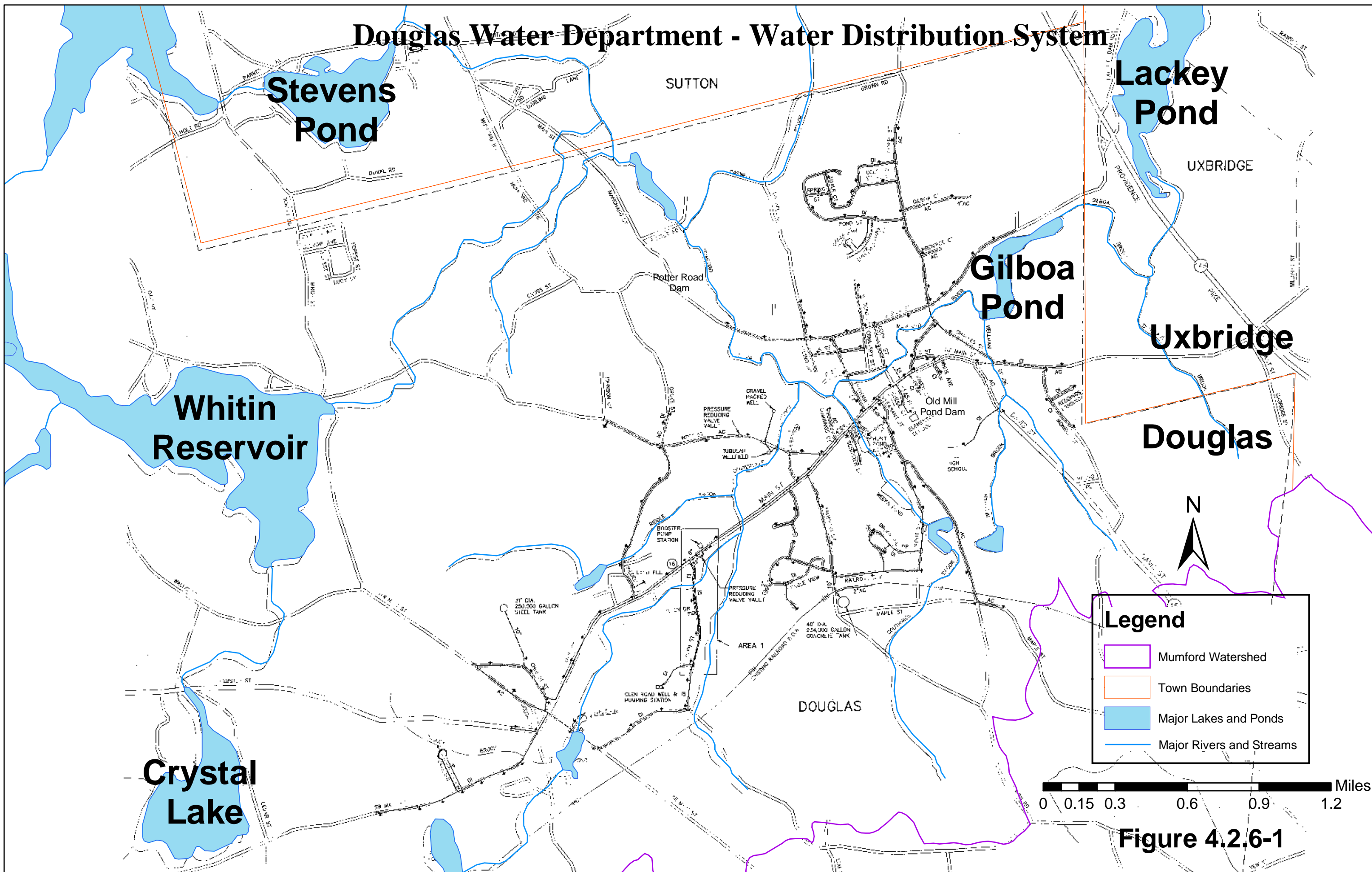


FIGURE 4.2.4-1

Douglas Water Department - Water Distribution System



Douglas Water Department - Sewer System

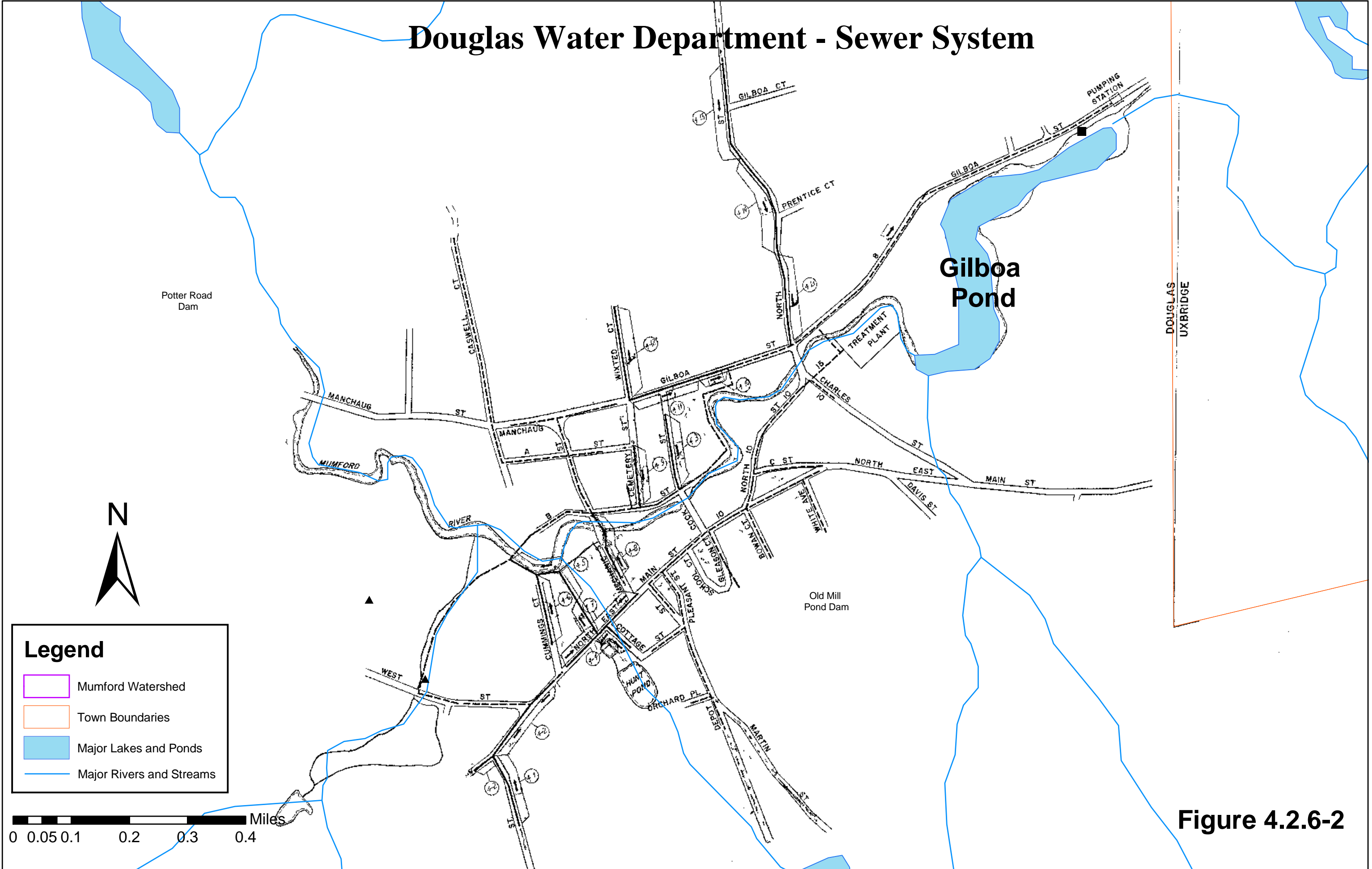


Figure 4.2.6-2

Comparison of East Douglas WWTP Discharges and Douglas Water Withdrawals, Averages for the Period 1998-2001

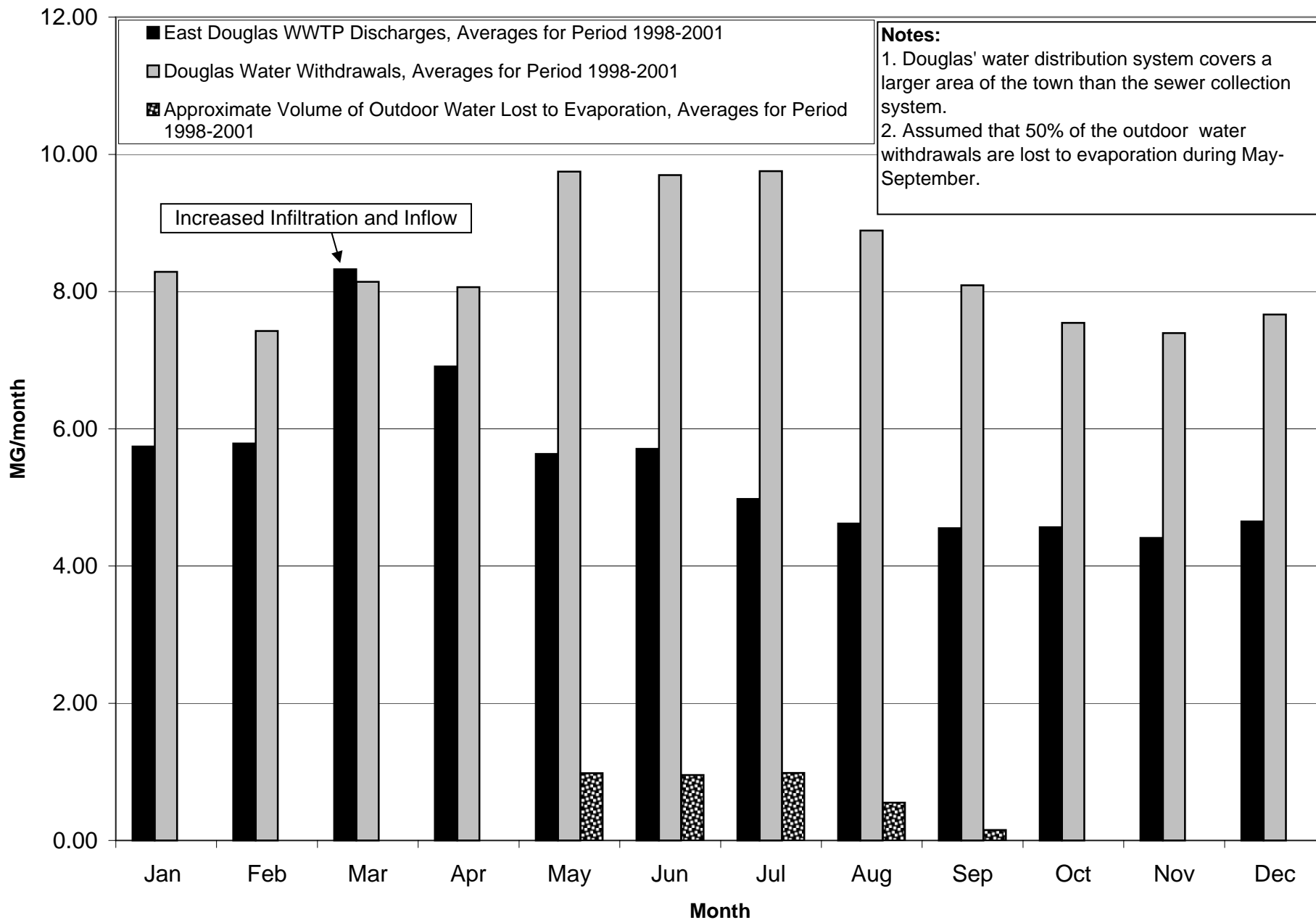


FIGURE 4.2.6-3

Interface Fabrics Group Finishing: Summary of Annual Water Usage from Gilboa Pond, 1998-2001

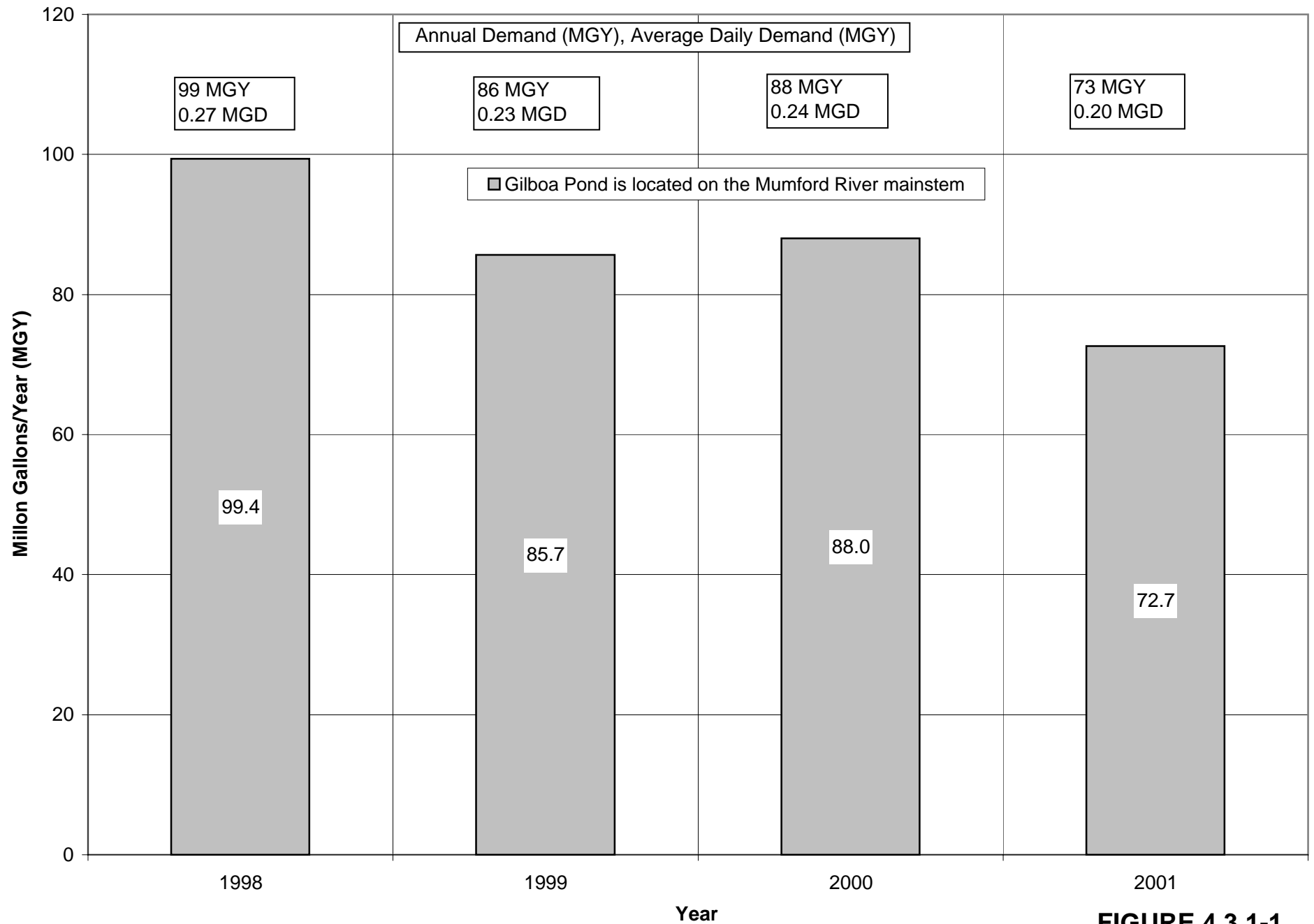


FIGURE 4.3.1-1

**Interface Fabrics Group Finishing: Water Usage on a Monthly Basis,
Averages Based on Period 1998-2001**

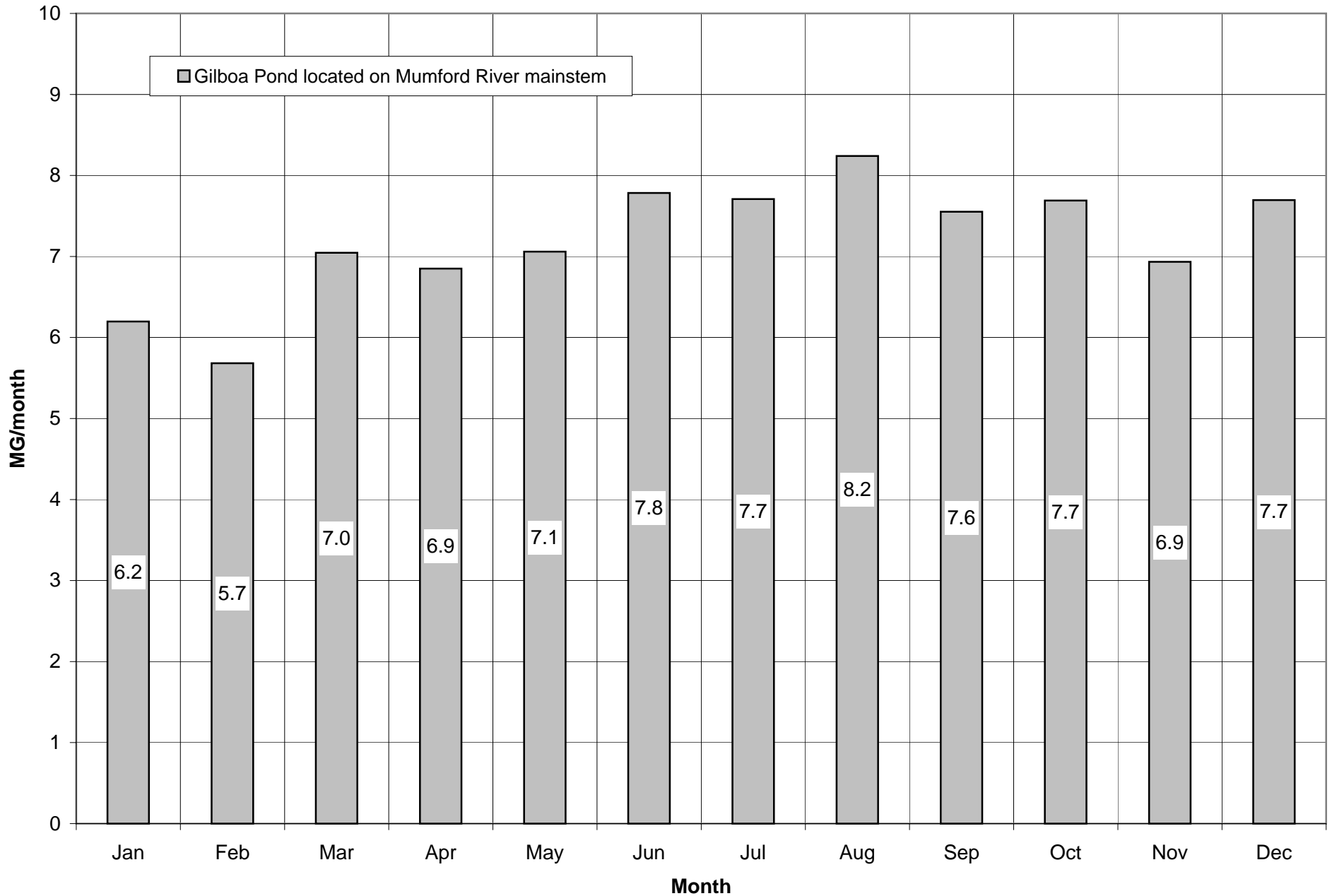


FIGURE 4.3.1-2

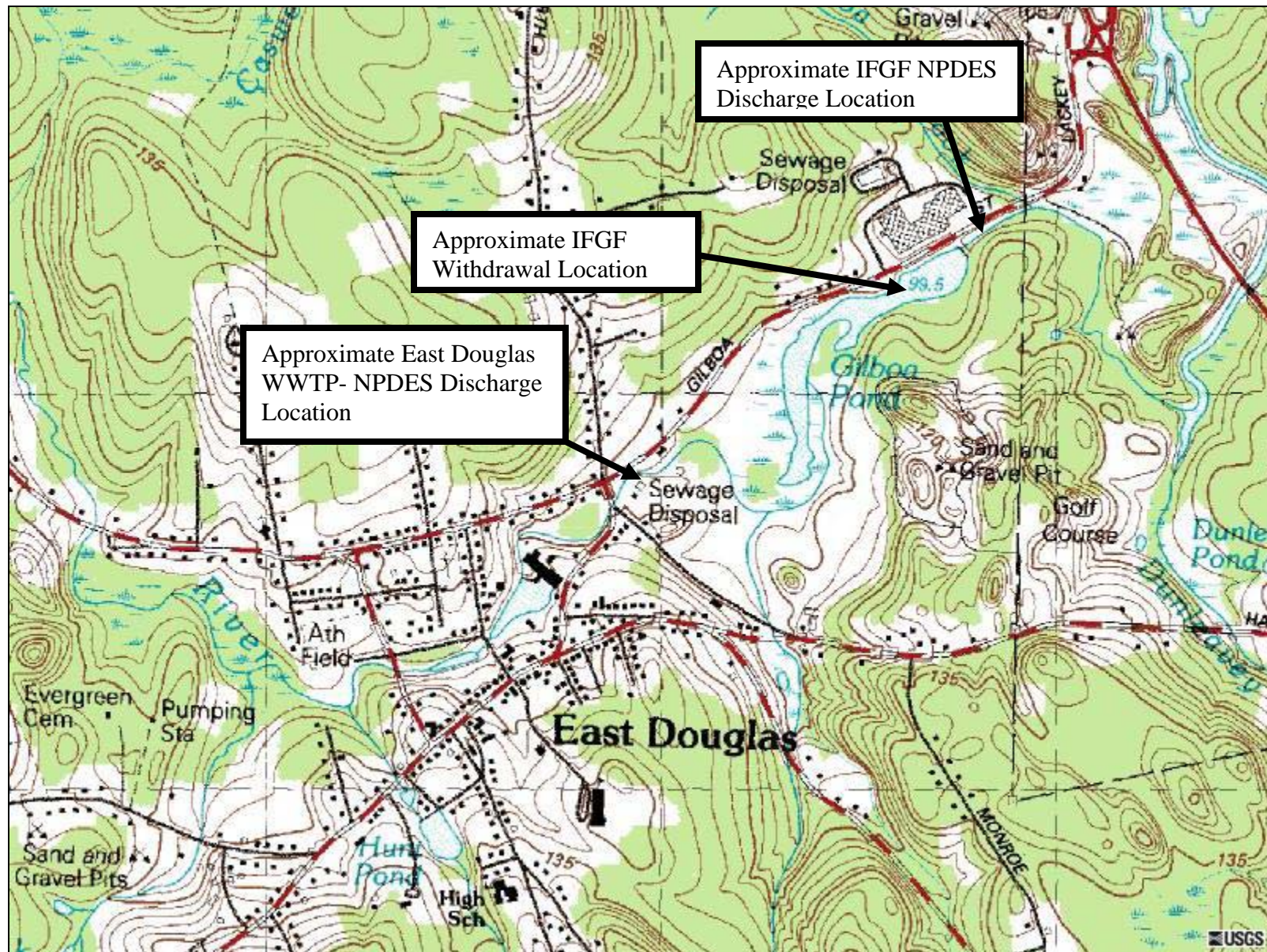


Figure 4.3.3-1: Location Map of the Interface Fabric Group Finishing, Inc. Water Withdrawal and NPDES Discharge Locations

**Interface Fabrics Group Finishing Monthly Water Withdrawal and Wastewater Discharge Volumes-
Averages based on the period Jan 1998-Dec 2001**

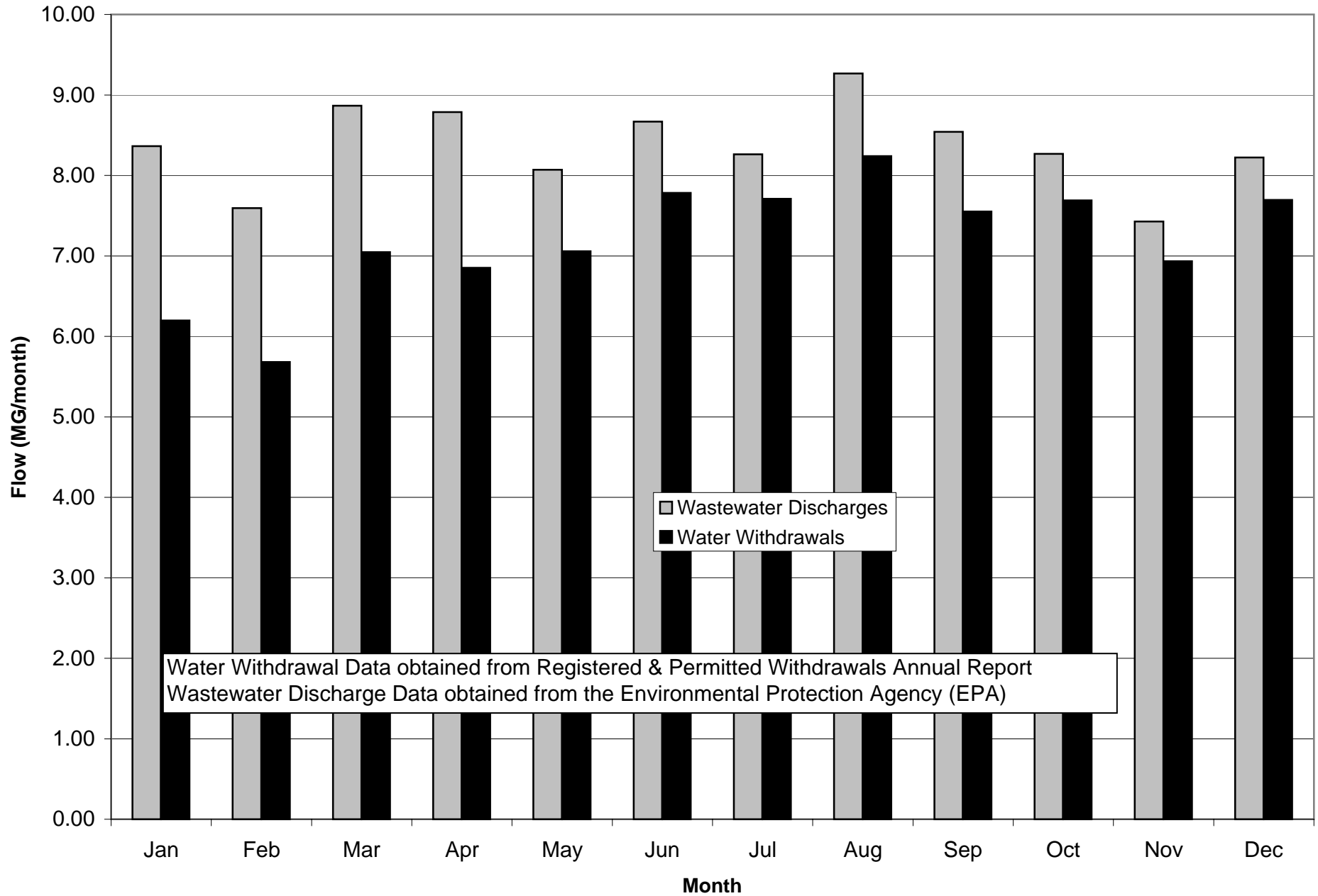


FIGURE 4.3.3-2

Interface Fabrics Group Finishing
Monthly Water Withdrawal and Wastewater Discharge Volumes- 2001

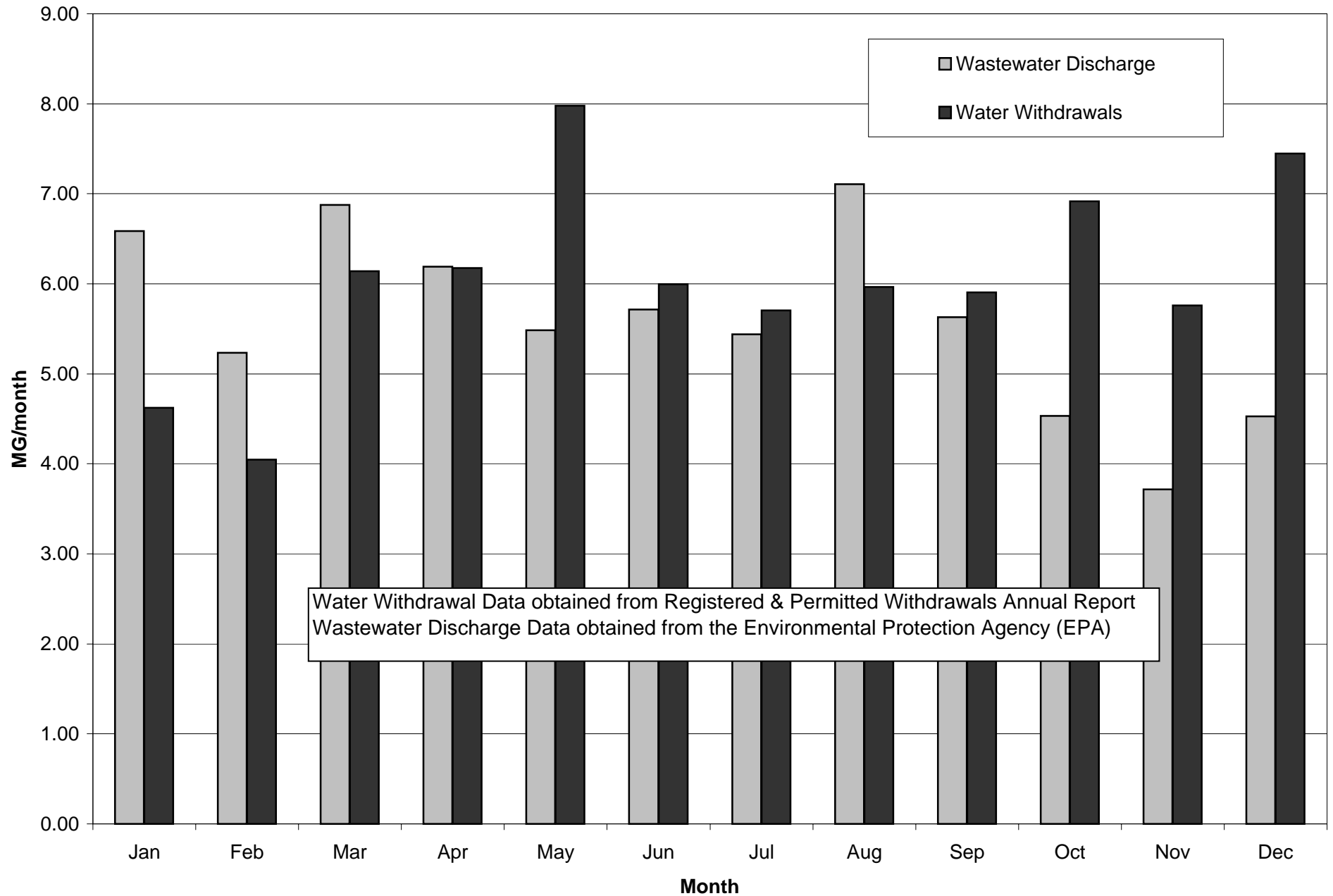


FIGURE 4.3.3-3

Whitinsville Golf Club: Summary of Water Usage, 1998-2001

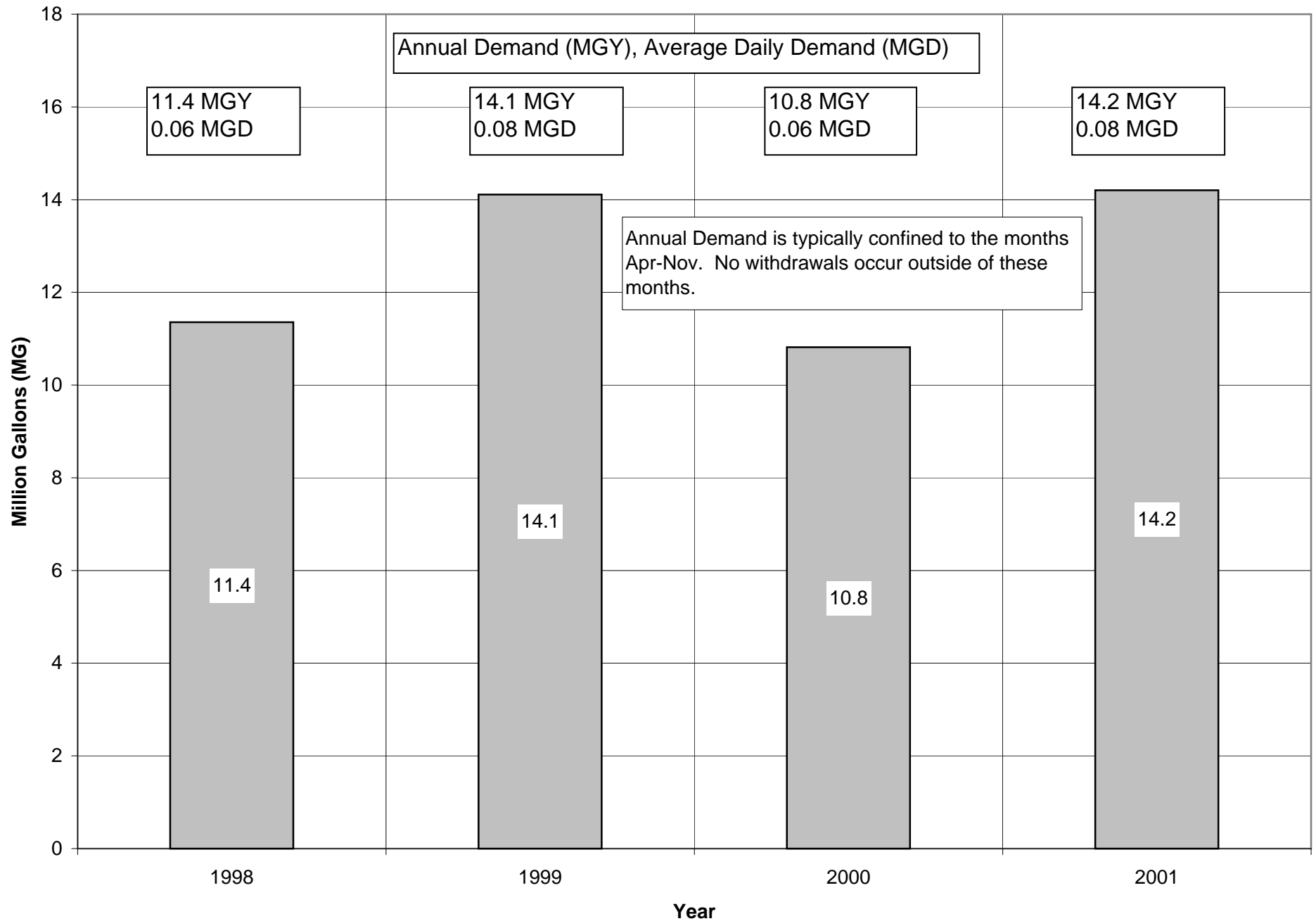


FIGURE 4.4.1-1

Whitinsville Golf Club: Water Usage on a Monthly Basis, Averages Based on Period 1998-2001

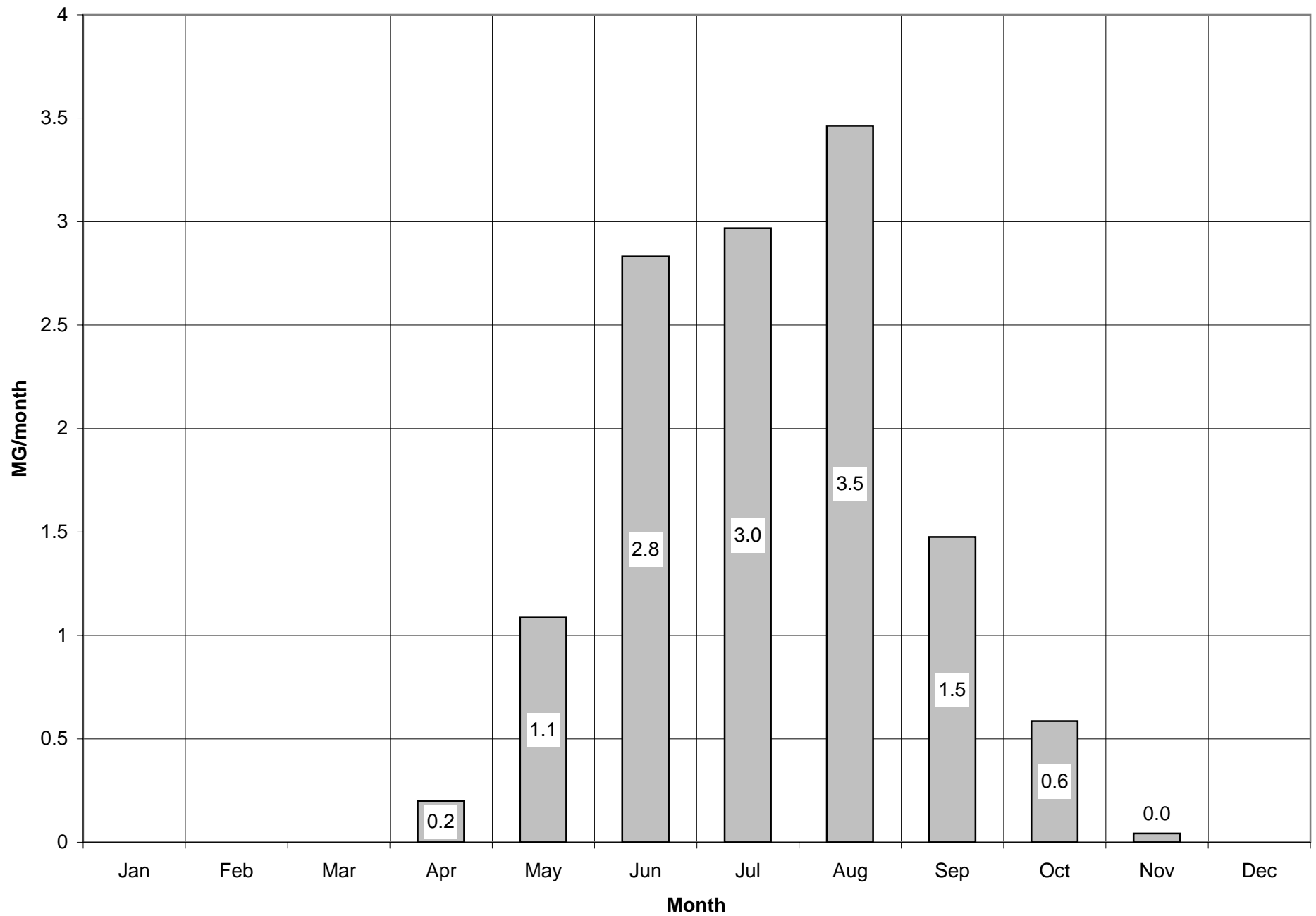


FIGURE 4.4.1-2

Whitinsville Golf Course- Estimated Water Returned and Lost from the Mumford River Basin

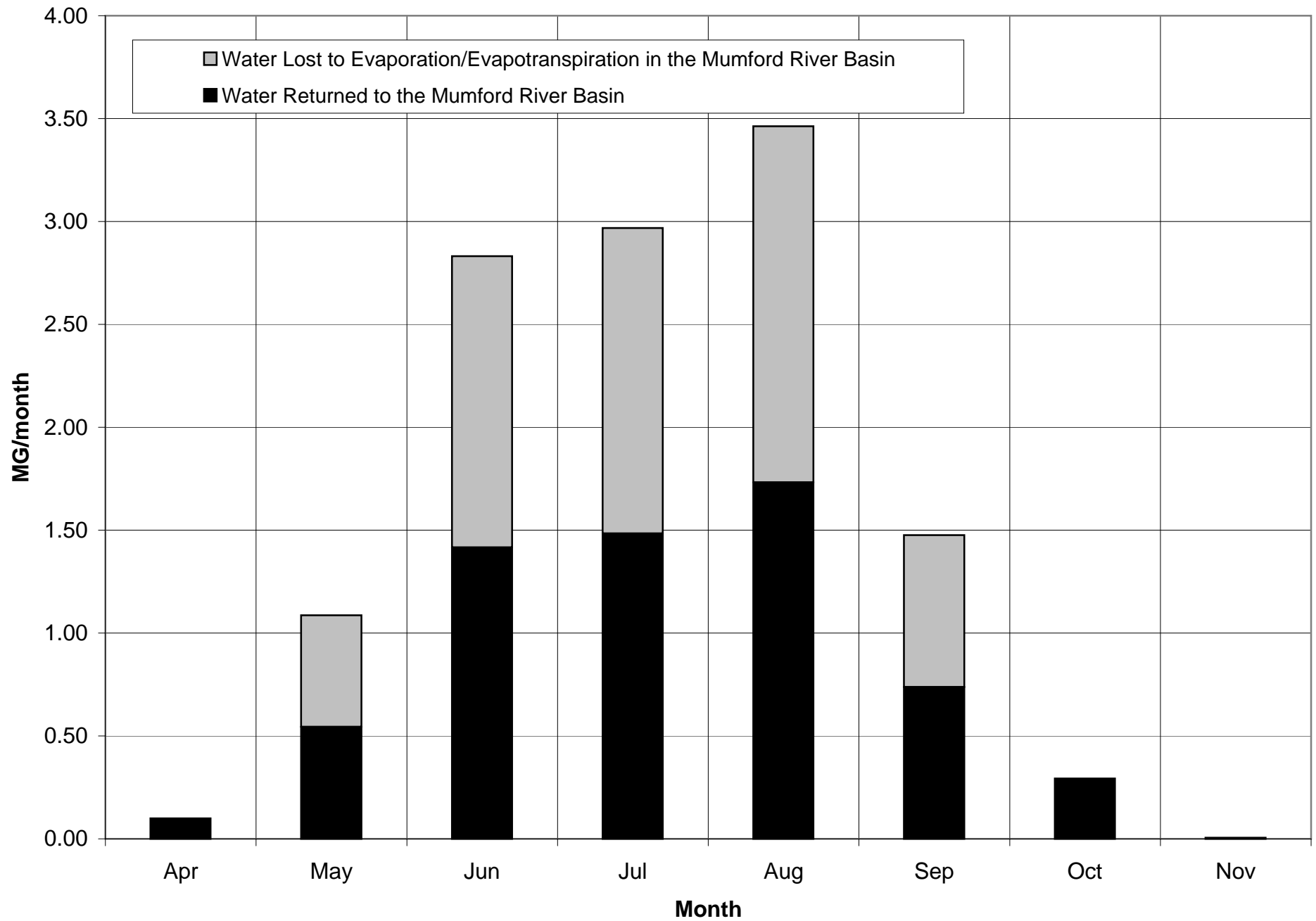


FIGURE 4.4.3-1

Average Annual Water Withdrawals (for the Period 1998-2001)- Comparison of four Water Management Act Withdrawals

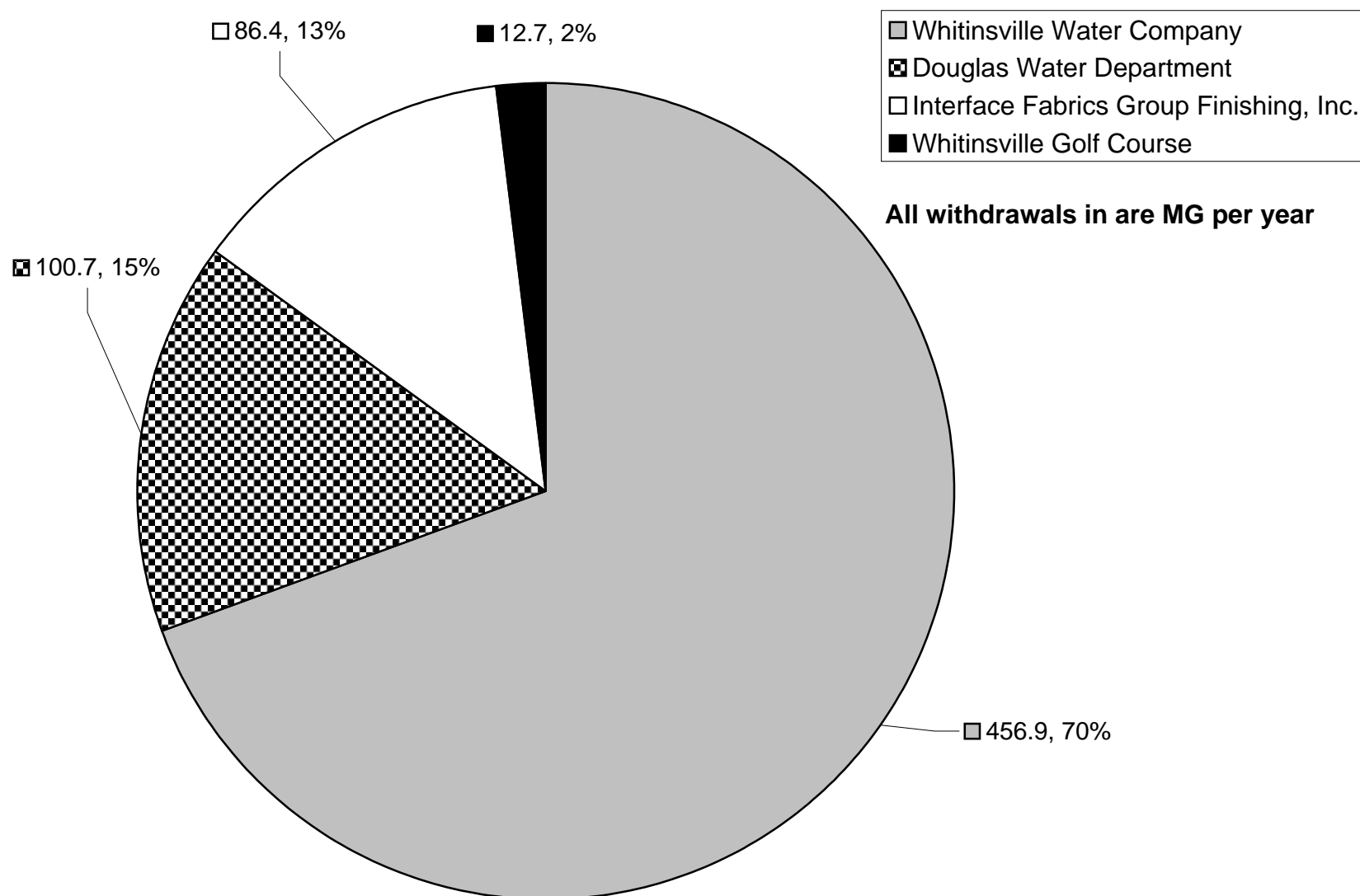


FIGURE 4.5.1-1

Average Monthly Water Withdrawals (for the Period 1998-2001)- Comparison of four Water Management Act Withdrawals

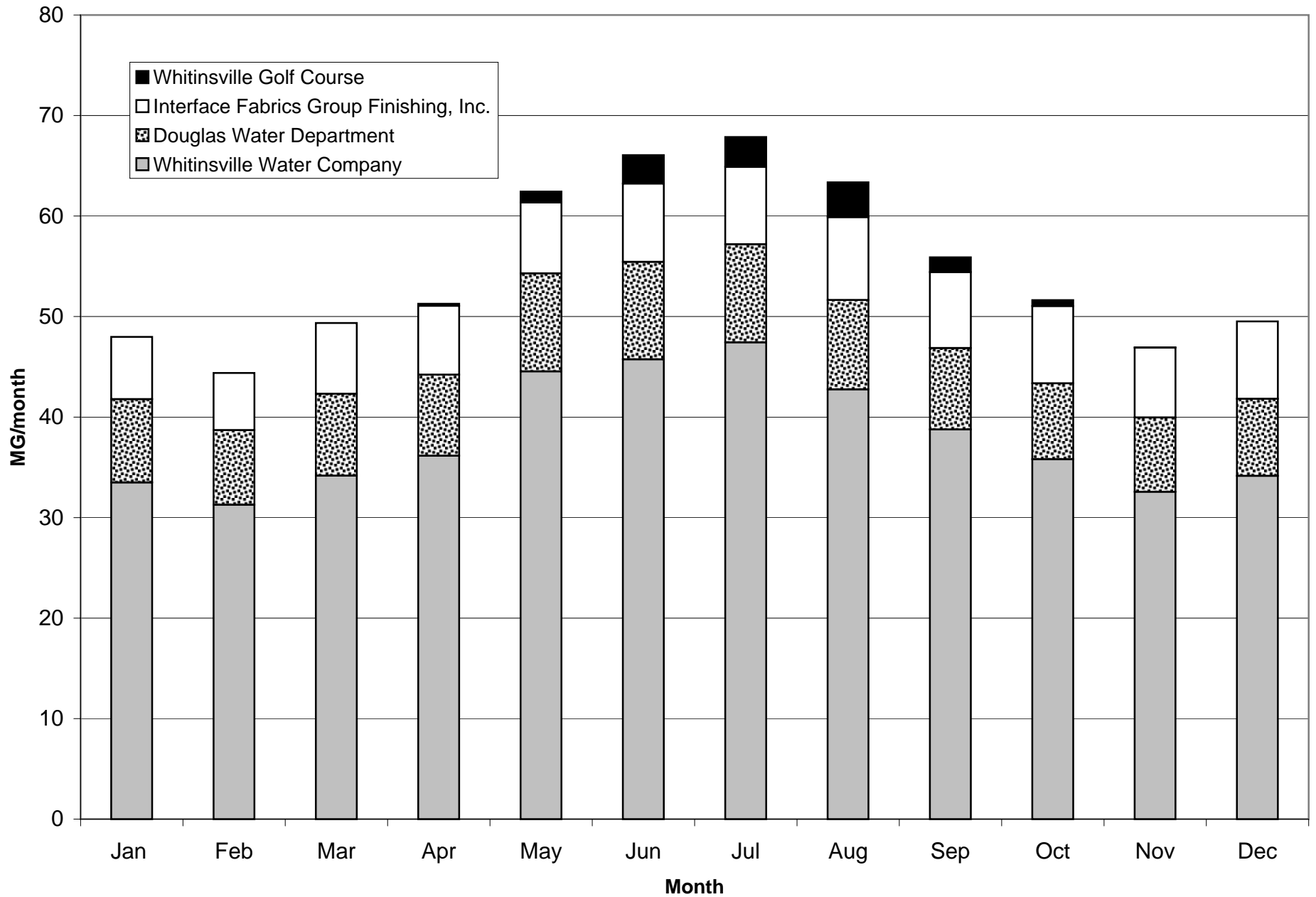


FIGURE 4.5.1-2

Estimated Losses from the Mumford River Basin from Whitinsville Water Company, Douglas Water Department and Whitinsville Golf Course (unquantifiable losses also occur from Interface Fabrics Group Finishing)- Averages for the Period 1998-2001

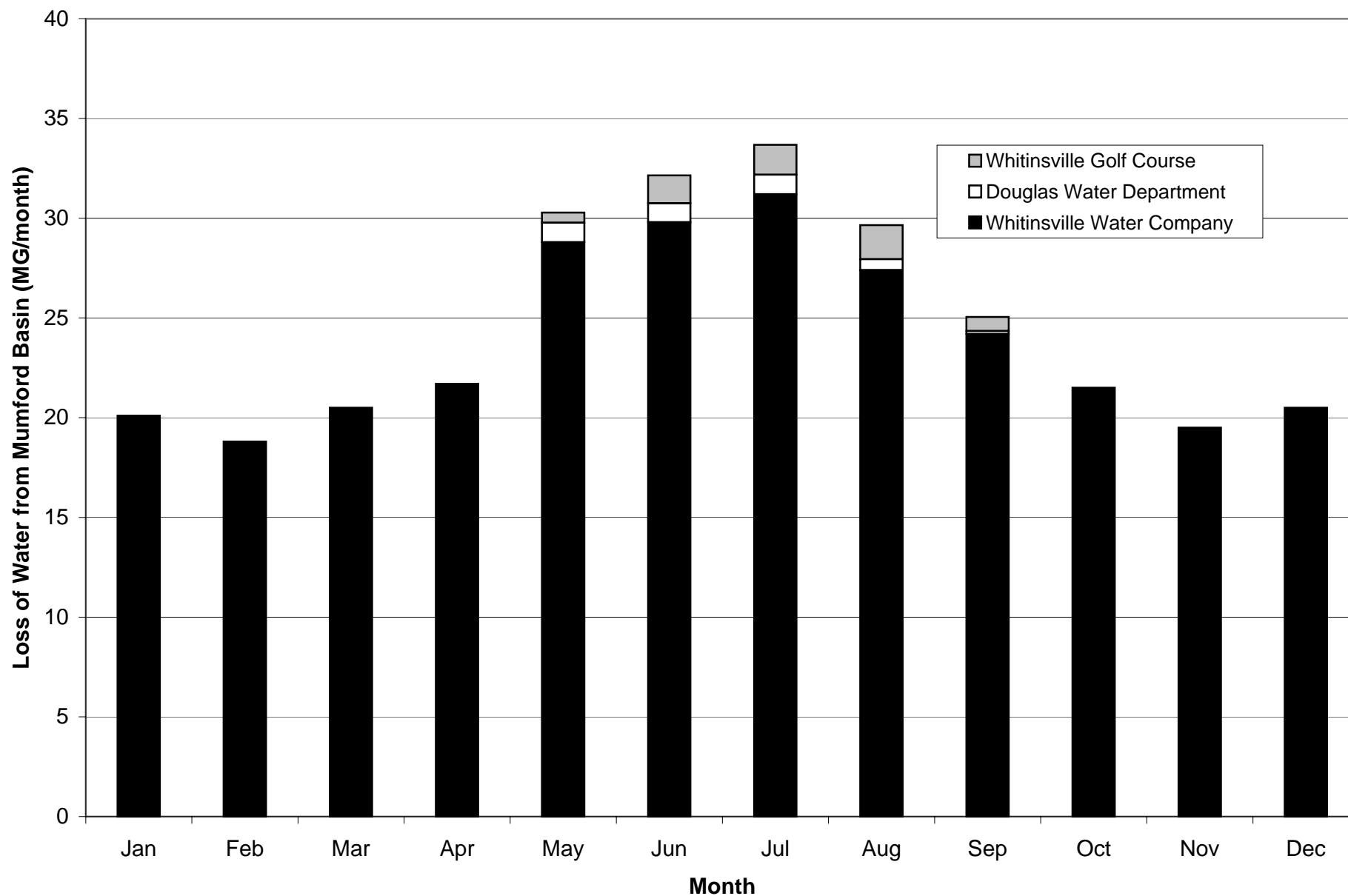


FIGURE 4.5.2-1

Douglas WWTP Monthly Discharge
Period: Average Daily Discharge for the Period January 1998-December 2001

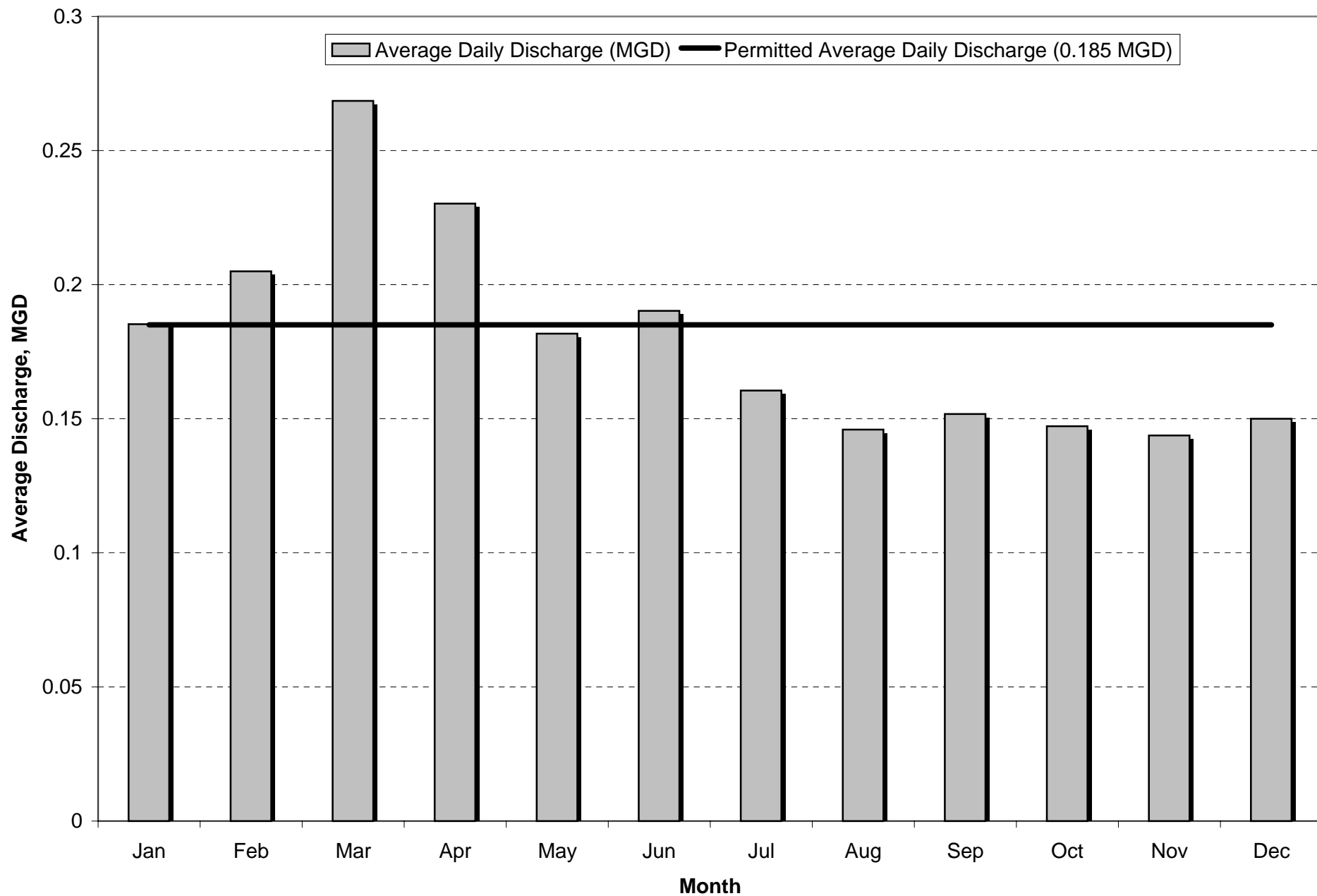


FIGURE 5.2-1

Interface Fabrics Group Finishing, Treatment Plant Monthly Discharge
Period: Average Daily Discharge for the Period January 1998-December 2001

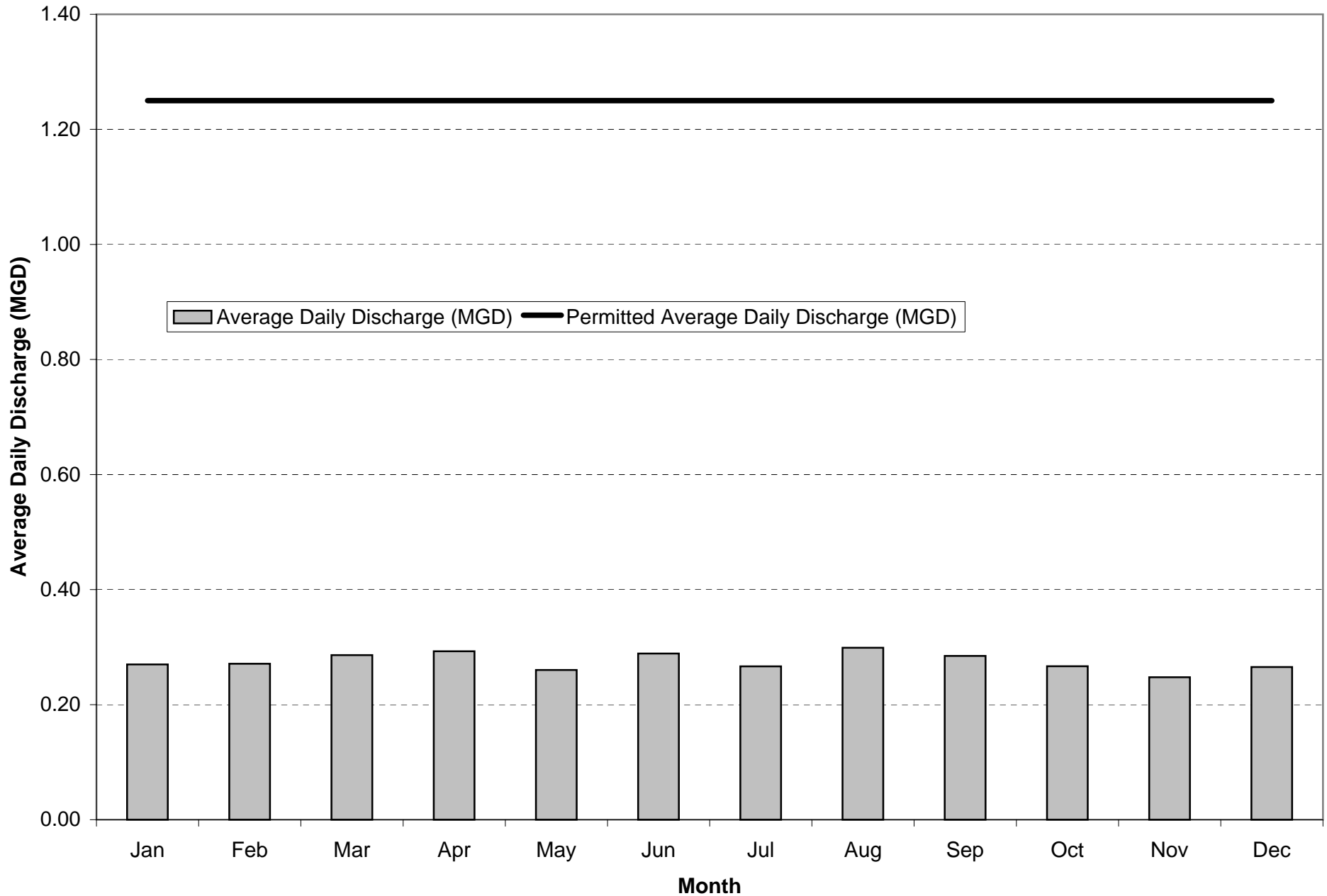


FIGURE 5.2-2

**USGS Gage on Mumford River near East Douglas, MA, Average of Mean Daily Flows for Period
Water Years 1940-1951, Drainage Area= 29.1 square miles**

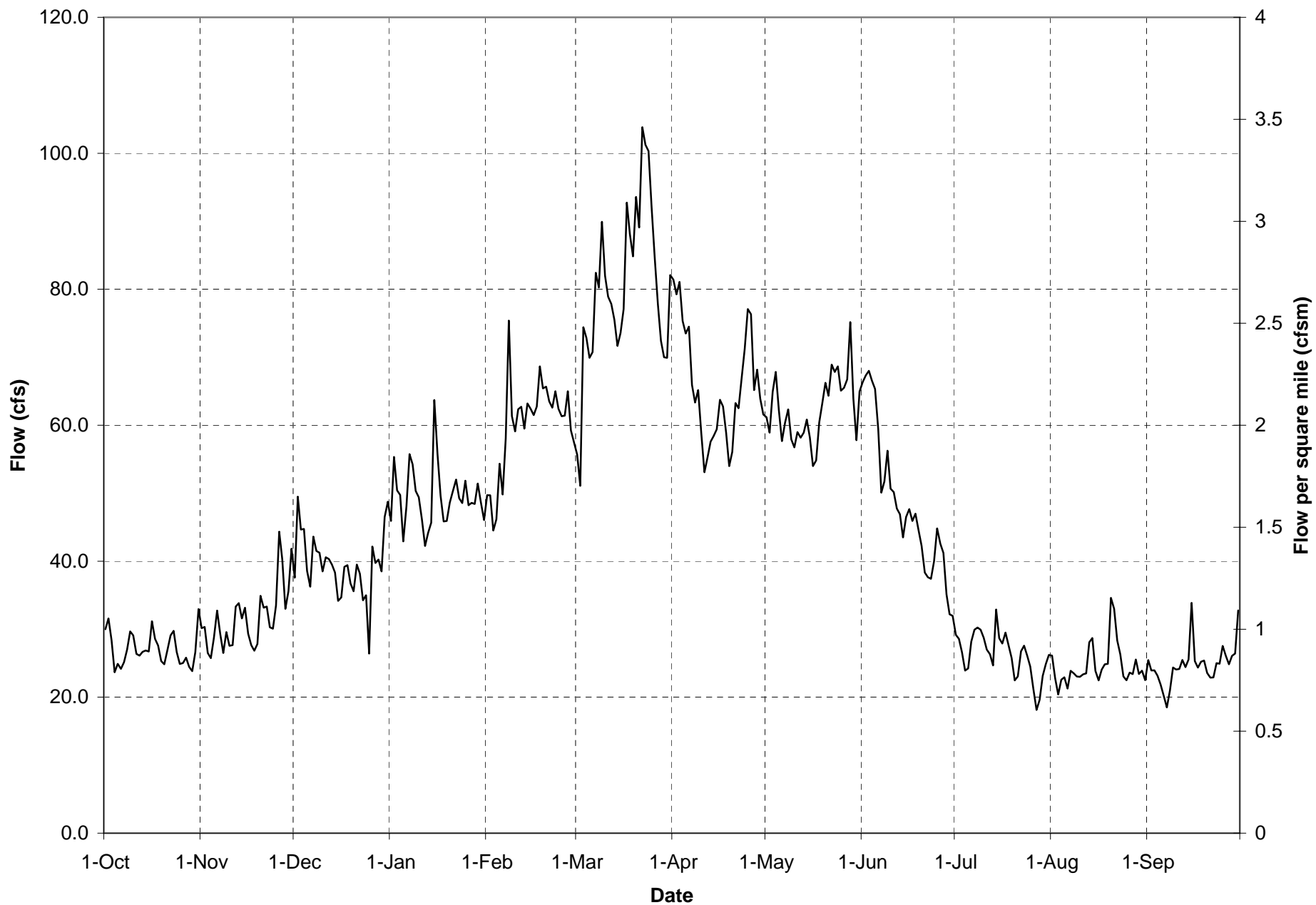


FIGURE 6.1-1

**USGS Gage on the Mumford River at East Douglas, MA, Average Daily Flow for Period
January 1, 1945-October 30, 1945, Drainage Area= 29.1 square miles**

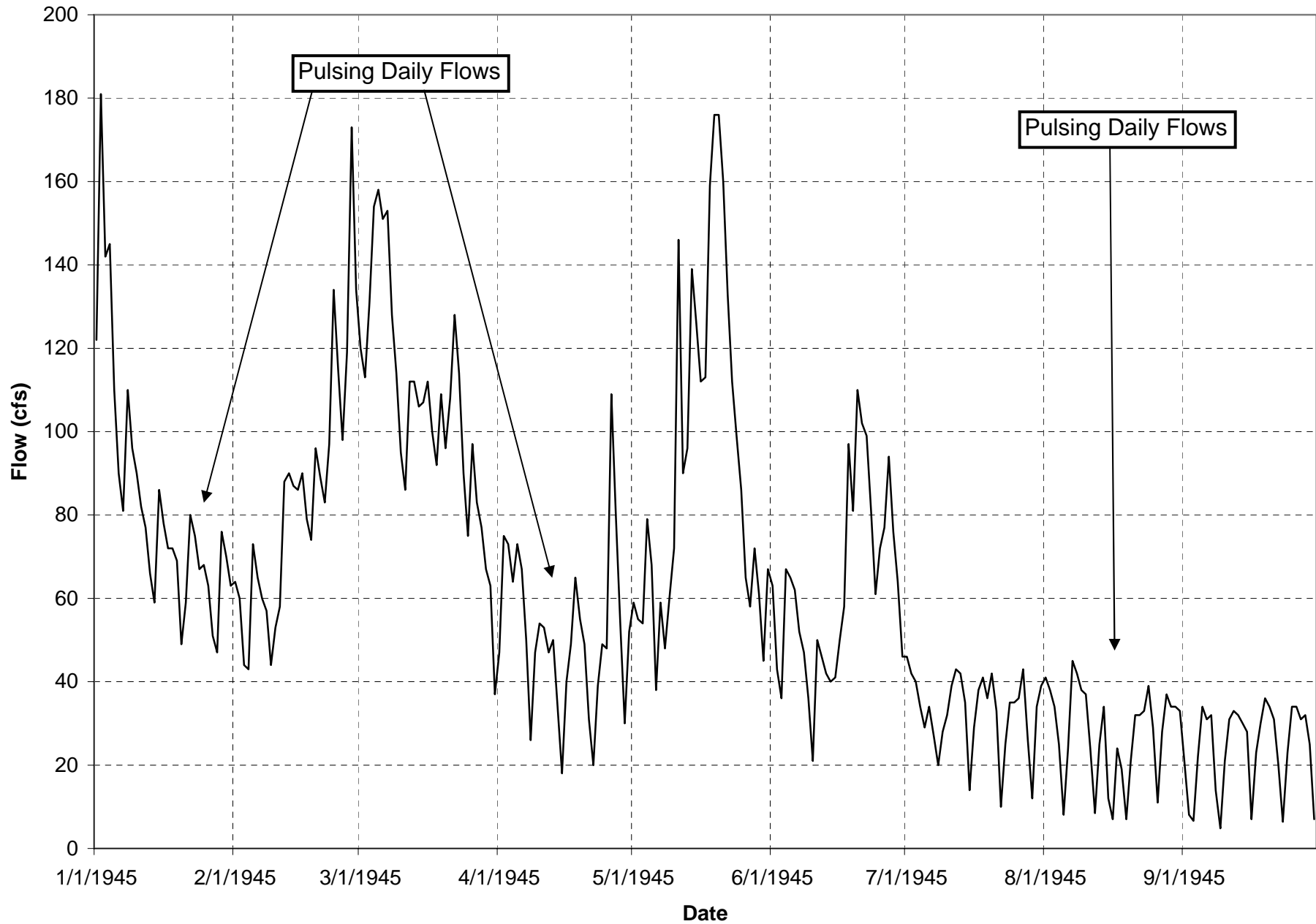


FIGURE 6.1-2

**USGS Gage on Mumford River near East Douglas, Mean Daily Flows for Period
July 1, 1941-September 30, 1941, Drainage Area= 29.1 square miles**

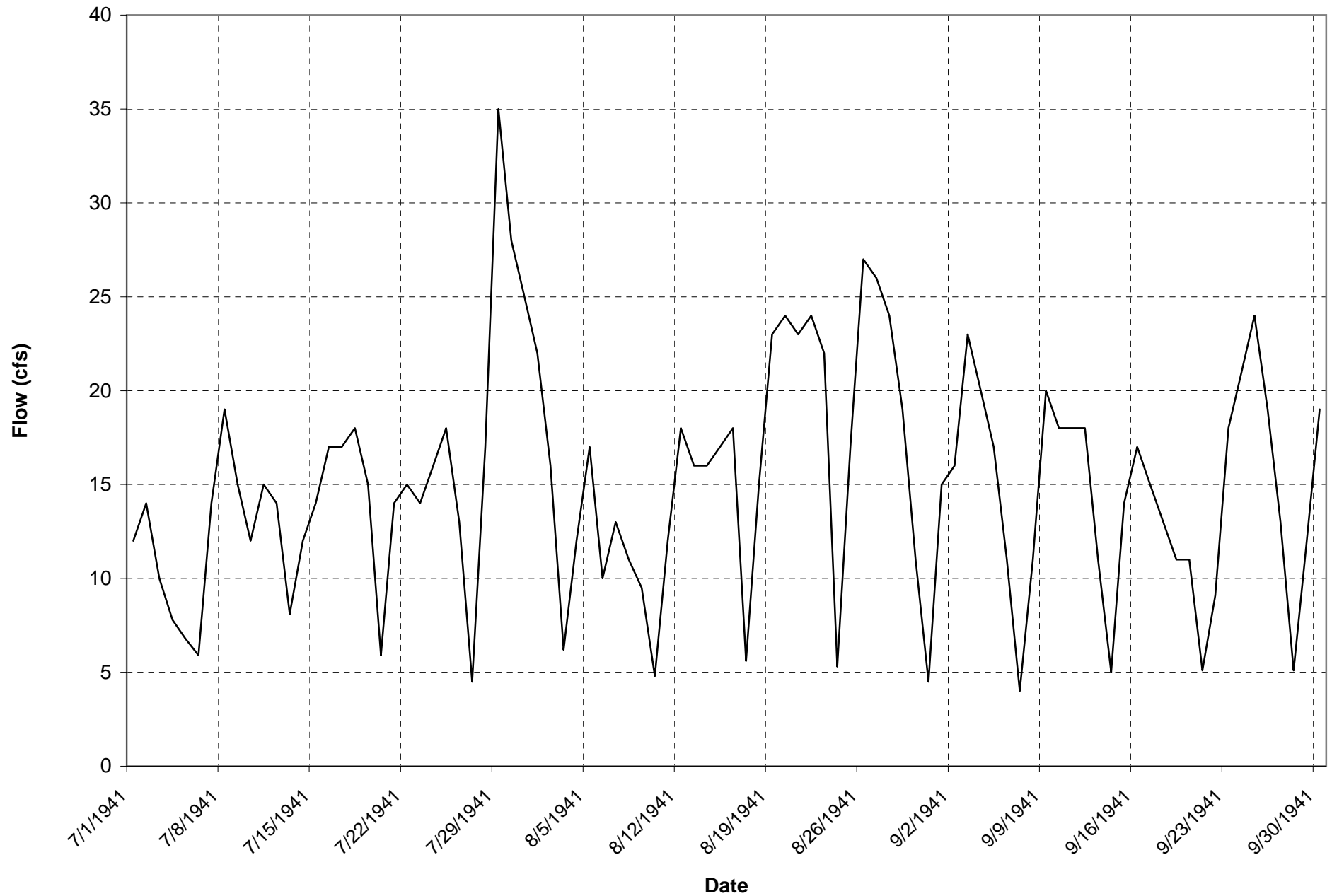


FIGURE 6.1-3

USGS Gage on Mumford River at East Douglas, MA, Average of the 7 lowest consecutive days flow
Period of Record: 1940-1951, Drainage Area= 29.1 sq mi

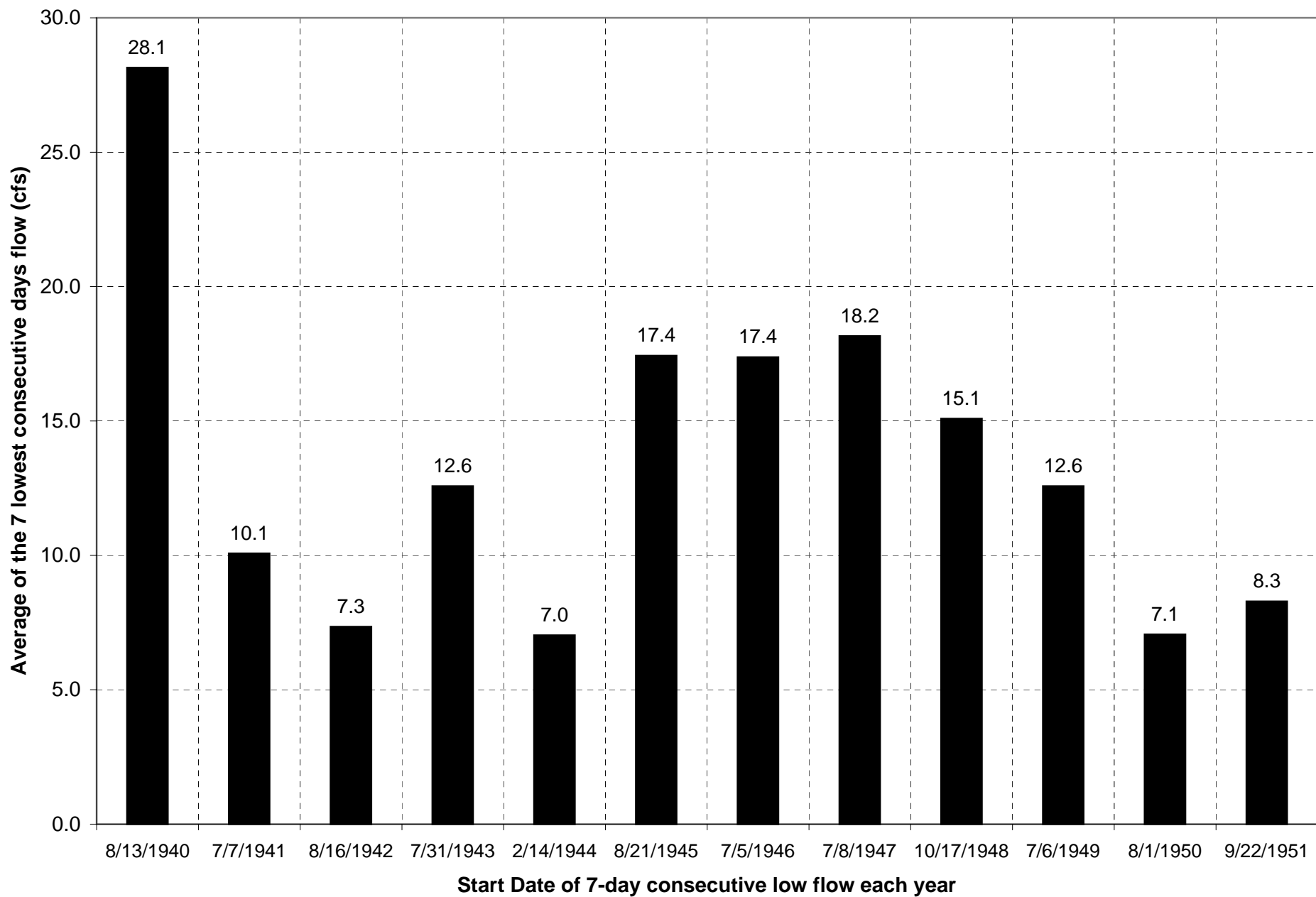


FIGURE 6.1-4

Manchaug Reservoir- 10-Year Average Rule Curve (Rule Curve prepared around 1936)

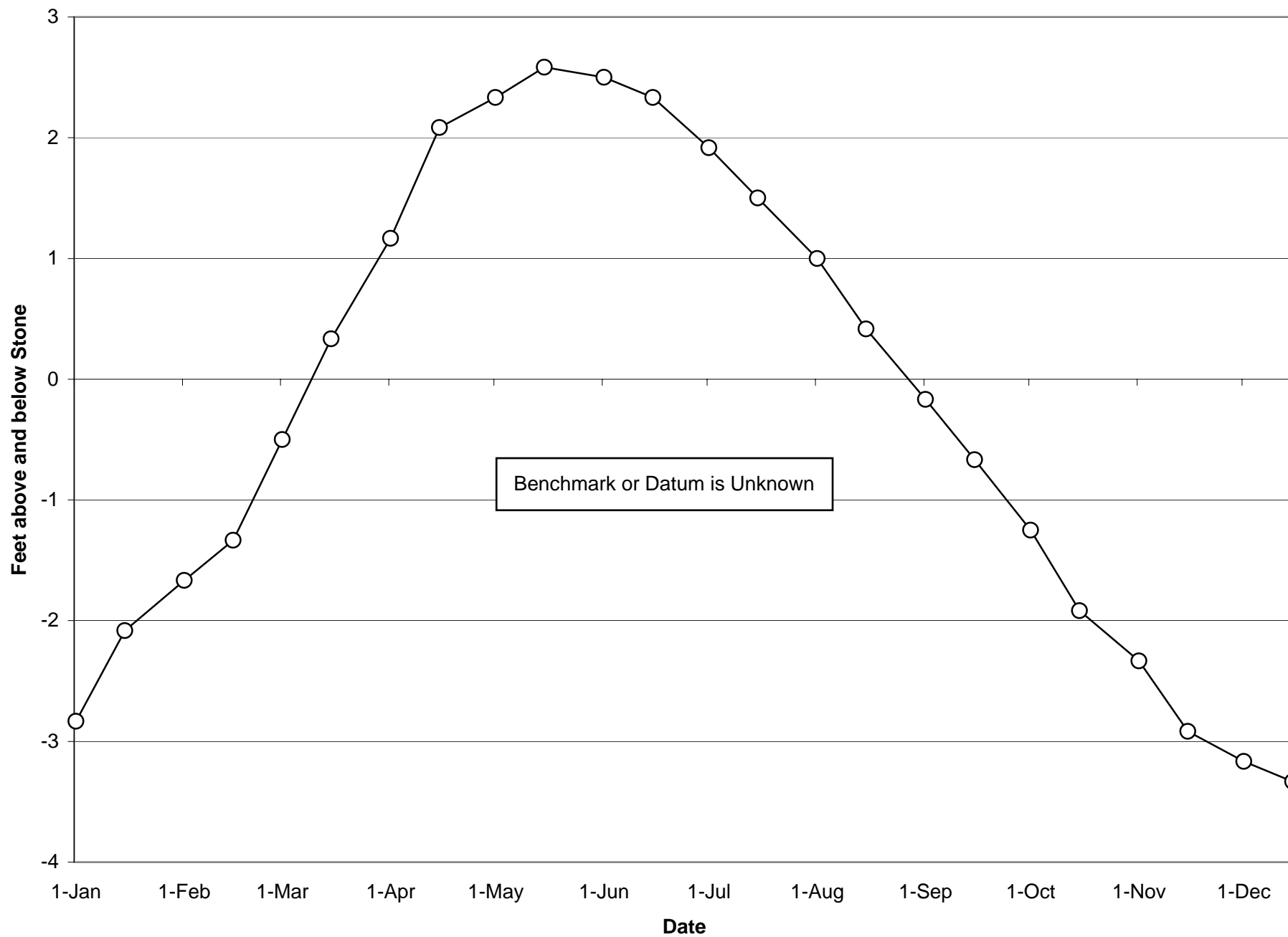


FIGURE 6.3-1

Whitin Reservoir- 10-Year Average Rule Curve (Rule Curve Prepared around 1936)

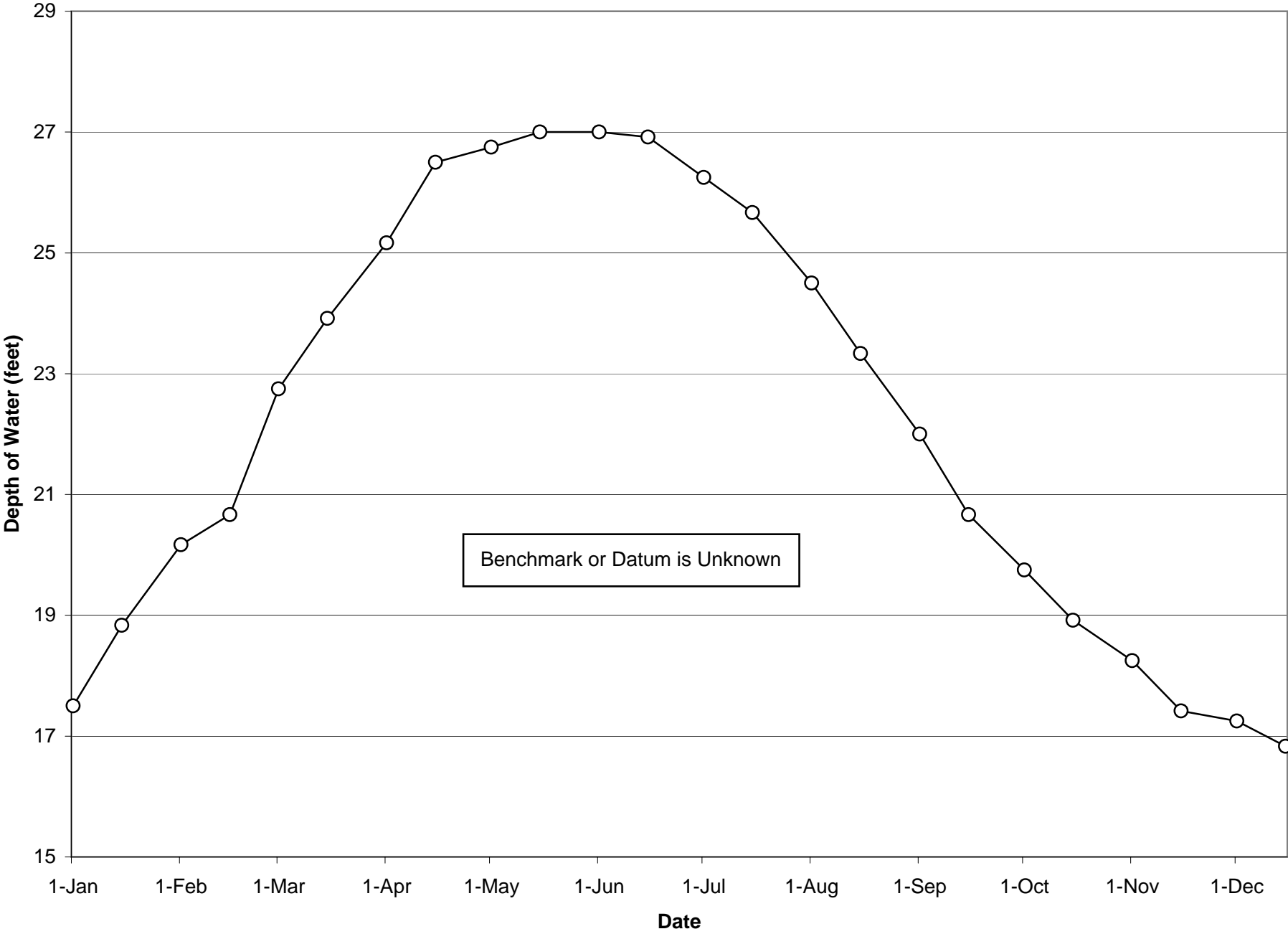


FIGURE 6.3-2

**Whitinsville Precipitation Gage- Monthly Totals for Calendar Years 1999-2002 Relative to the Period
of Record Percentiles**

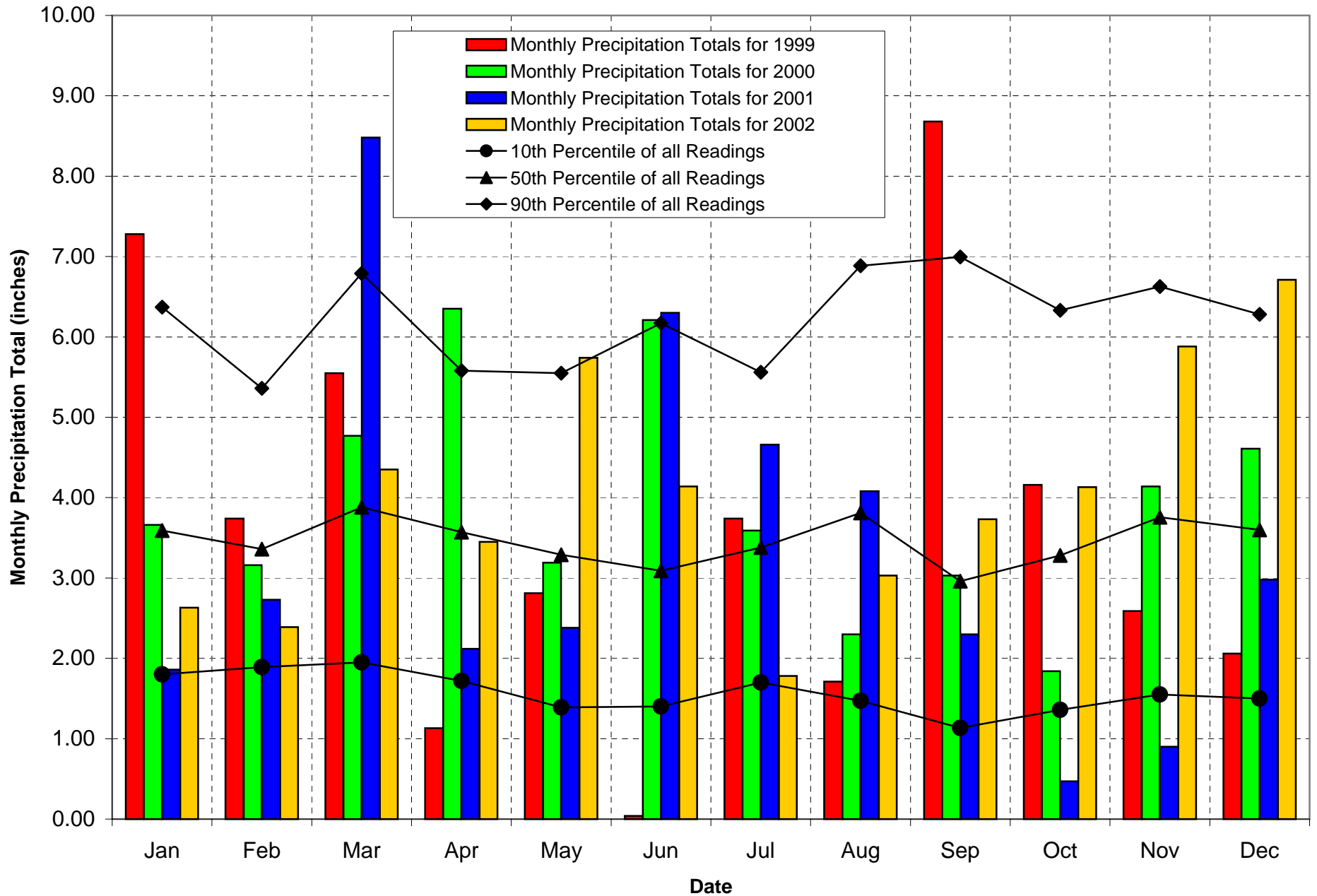


FIGURE 6.4-1

Relationship between Mumford River Flow in Douglas (as recorded by IFGF) and Precipitation (as recorded in Whitinsville)- Calendar Year 1999

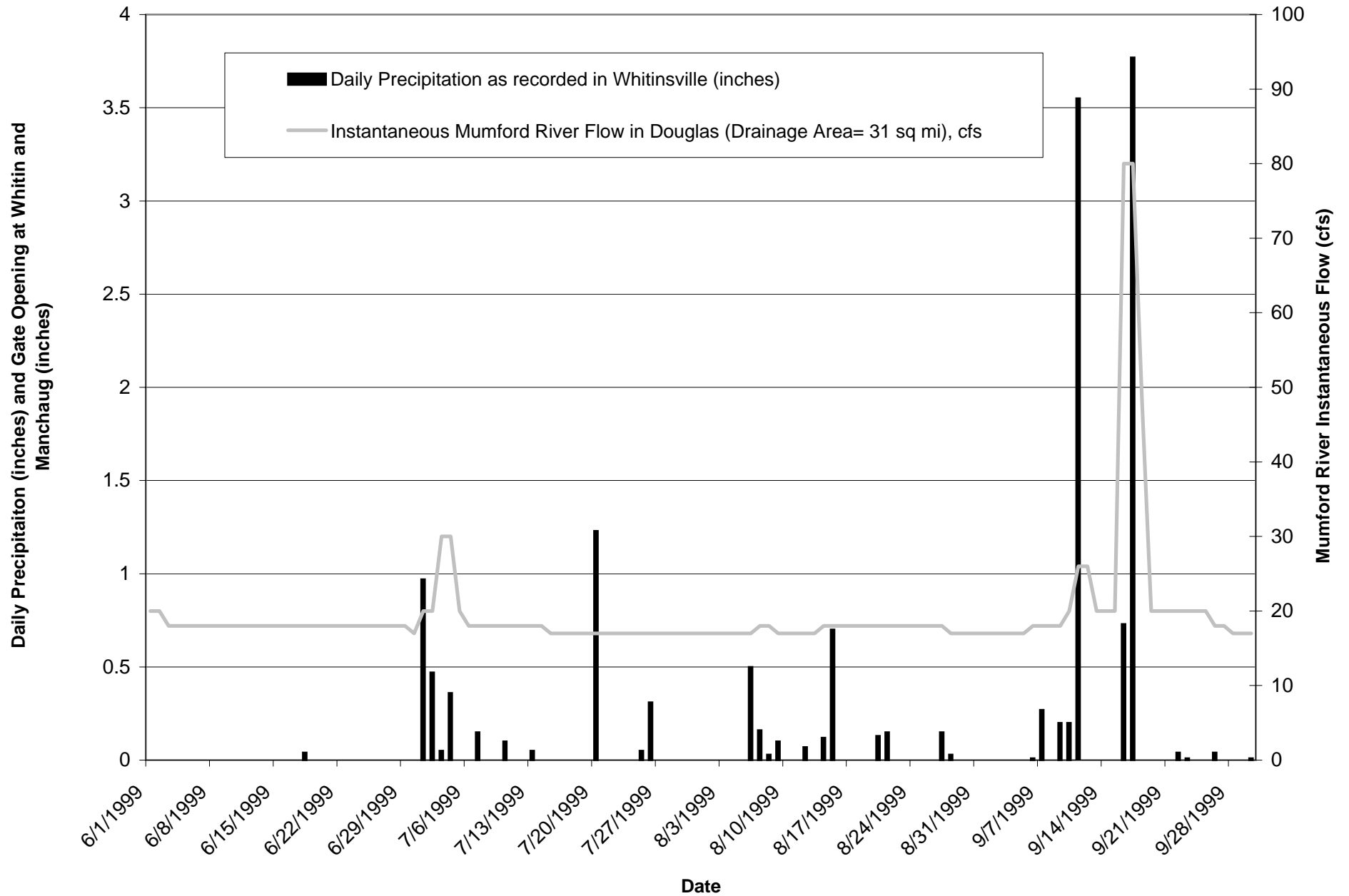


FIGURE 6.4-2

Relationship between Mumford River Flow in Douglas (as recorded by IFGF) and Precipitation (as recorded in Whitinsville)- Calendar Year 2000

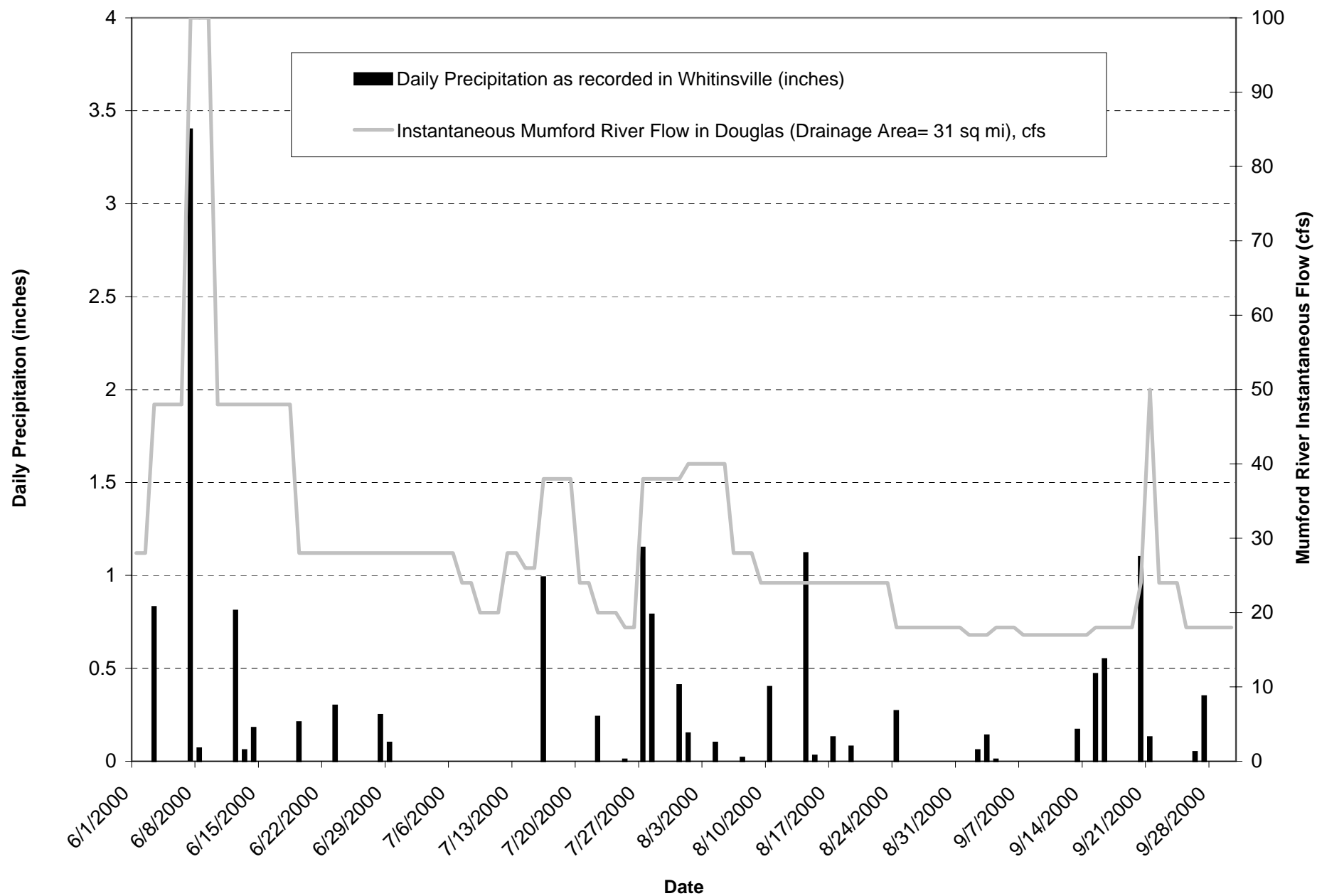


FIGURE 6.4-3

Relationship between Mumford River Flow in Douglas (as recorded by IFGF) and Precipitation (as recorded in Whitinsville)- Calendar Year 2001

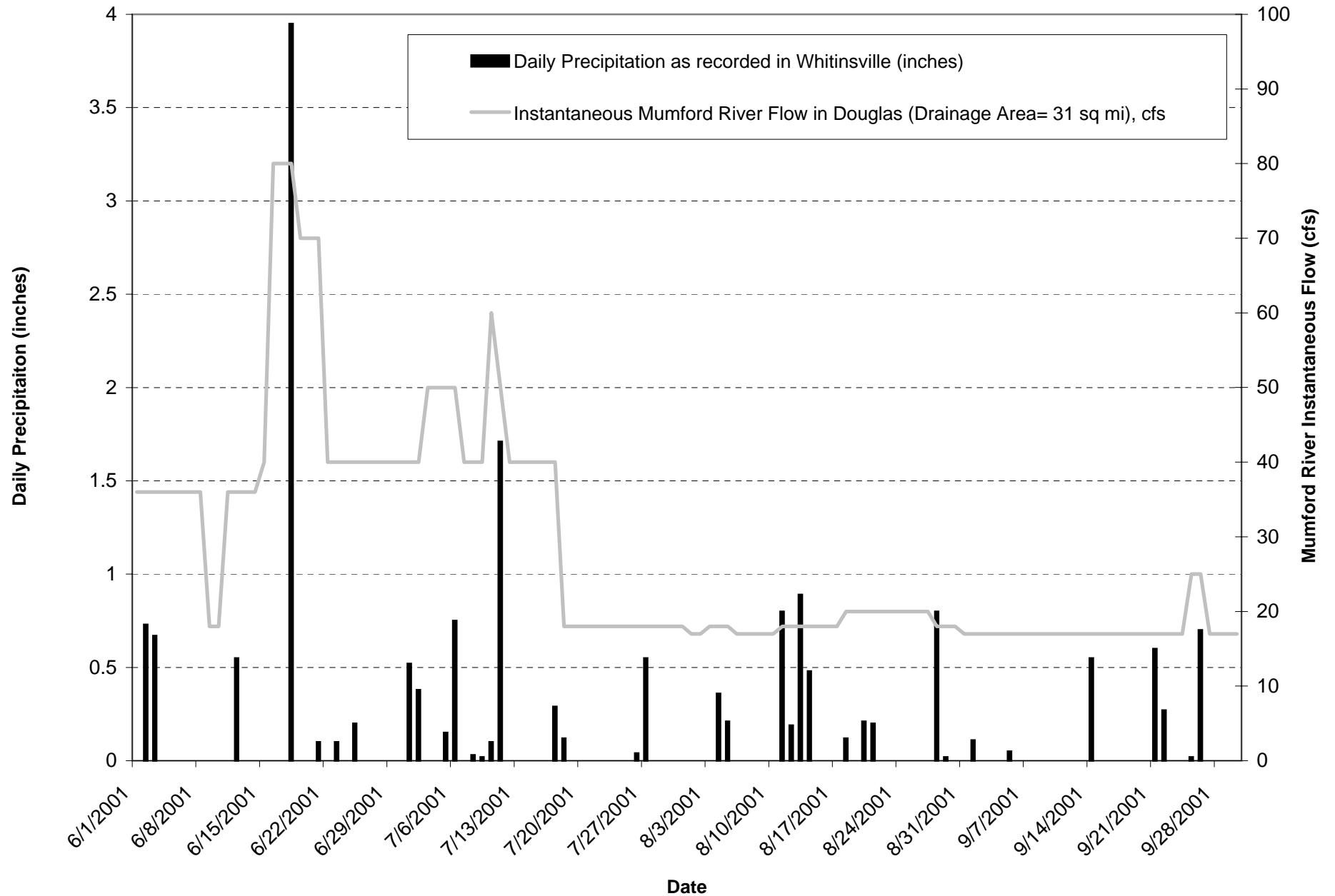


FIGURE 6.4-4

Relationship between Mumford River Flow in Douglas (as recorded by IFGF) and Precipitation (as recorded in Whitinsville)- Calendar Year 2002

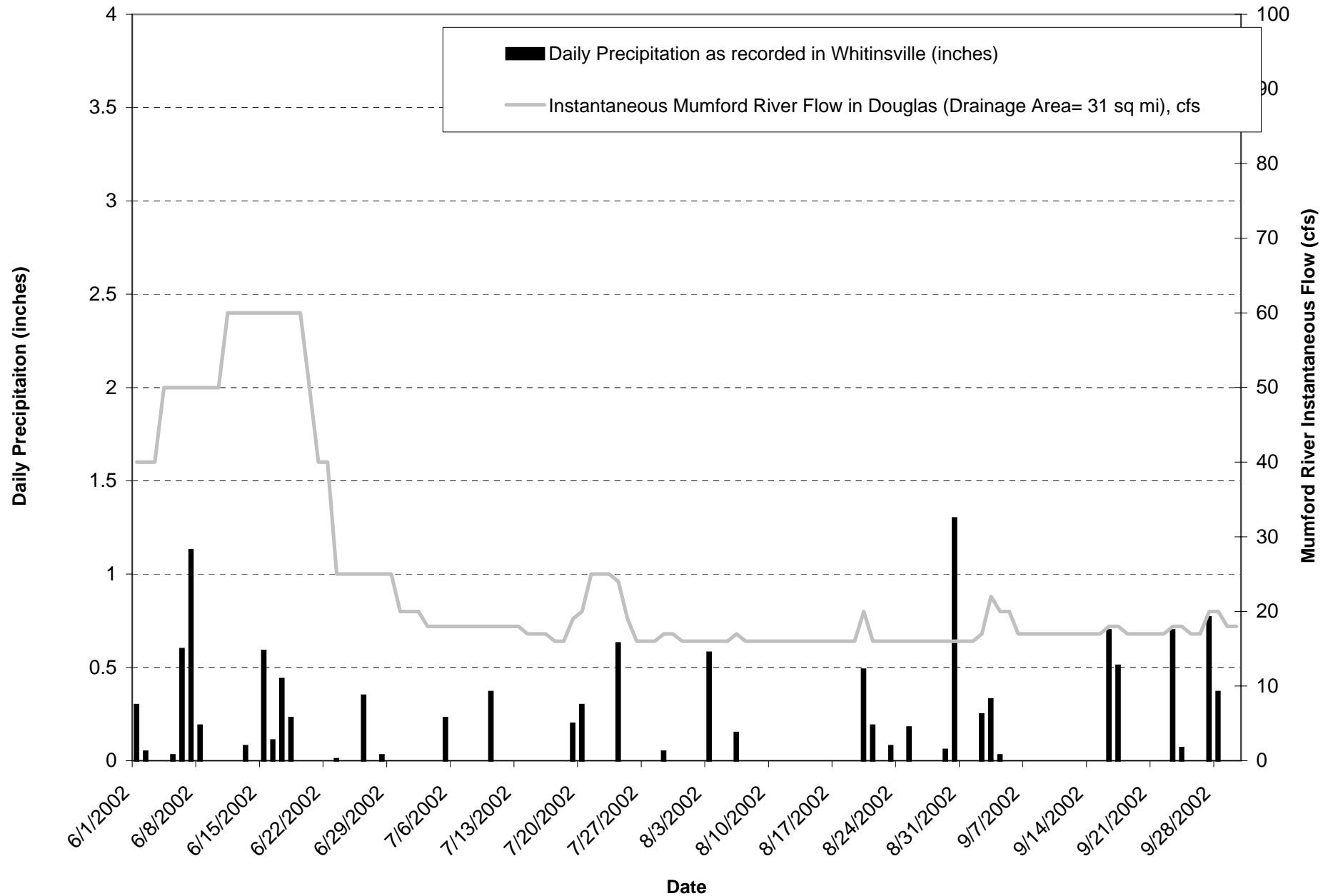


FIGURE 6.4-5

Relationship between Mumford River Flow in Douglas (as recorded by IFGF), Precipitation (as recorded in Whitinsville), and Manchaug & Whitin Reservoir Gate Openings- Calendar Year 1999

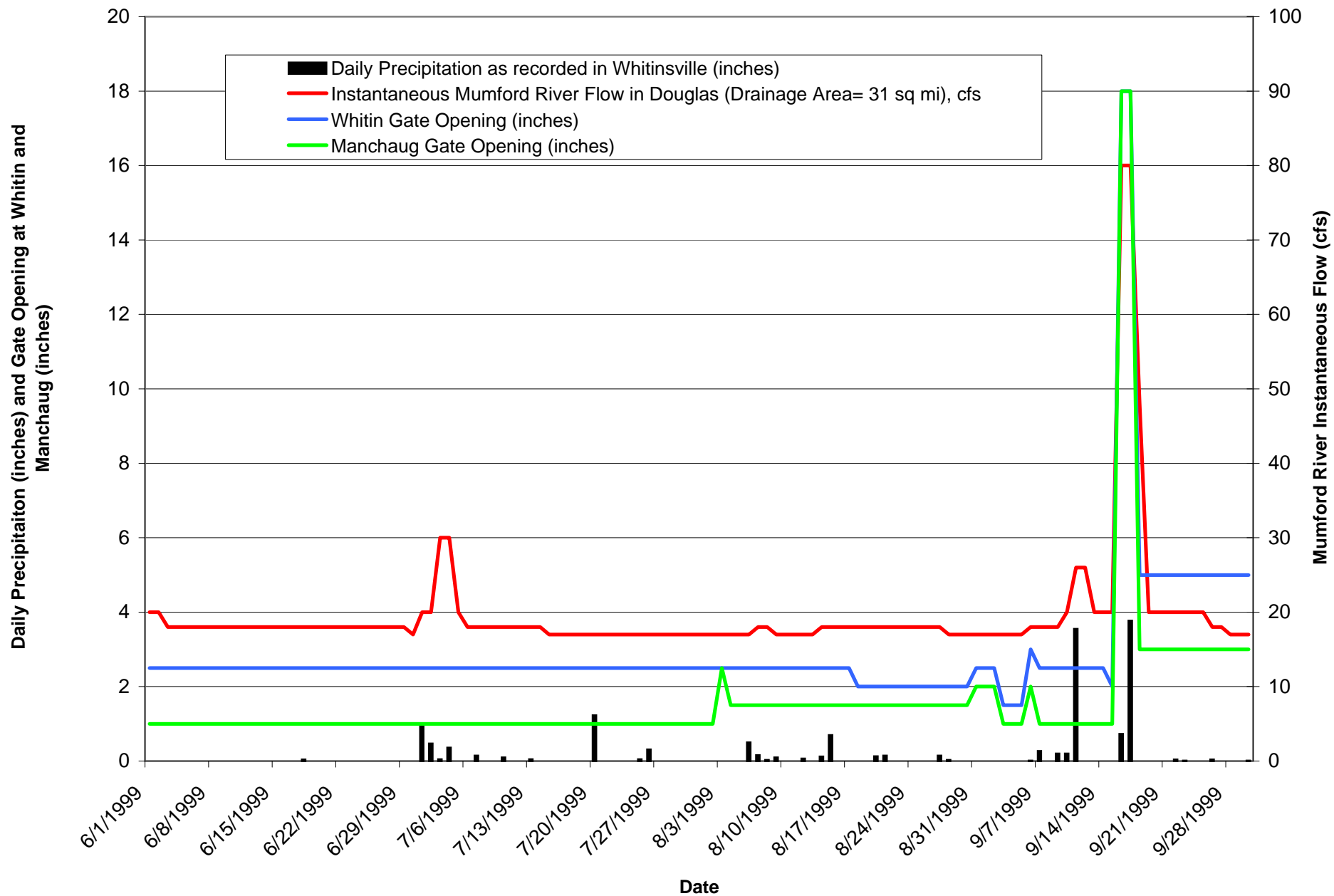


FIGURE 6.4-6

Relationship between Mumford River Flow in Douglas (as recorded by IFGF), Precipitation (as recorded in Whitinsville), and Manchaug & Whitin Reservoir Gate Openings- Calendar Year 2000

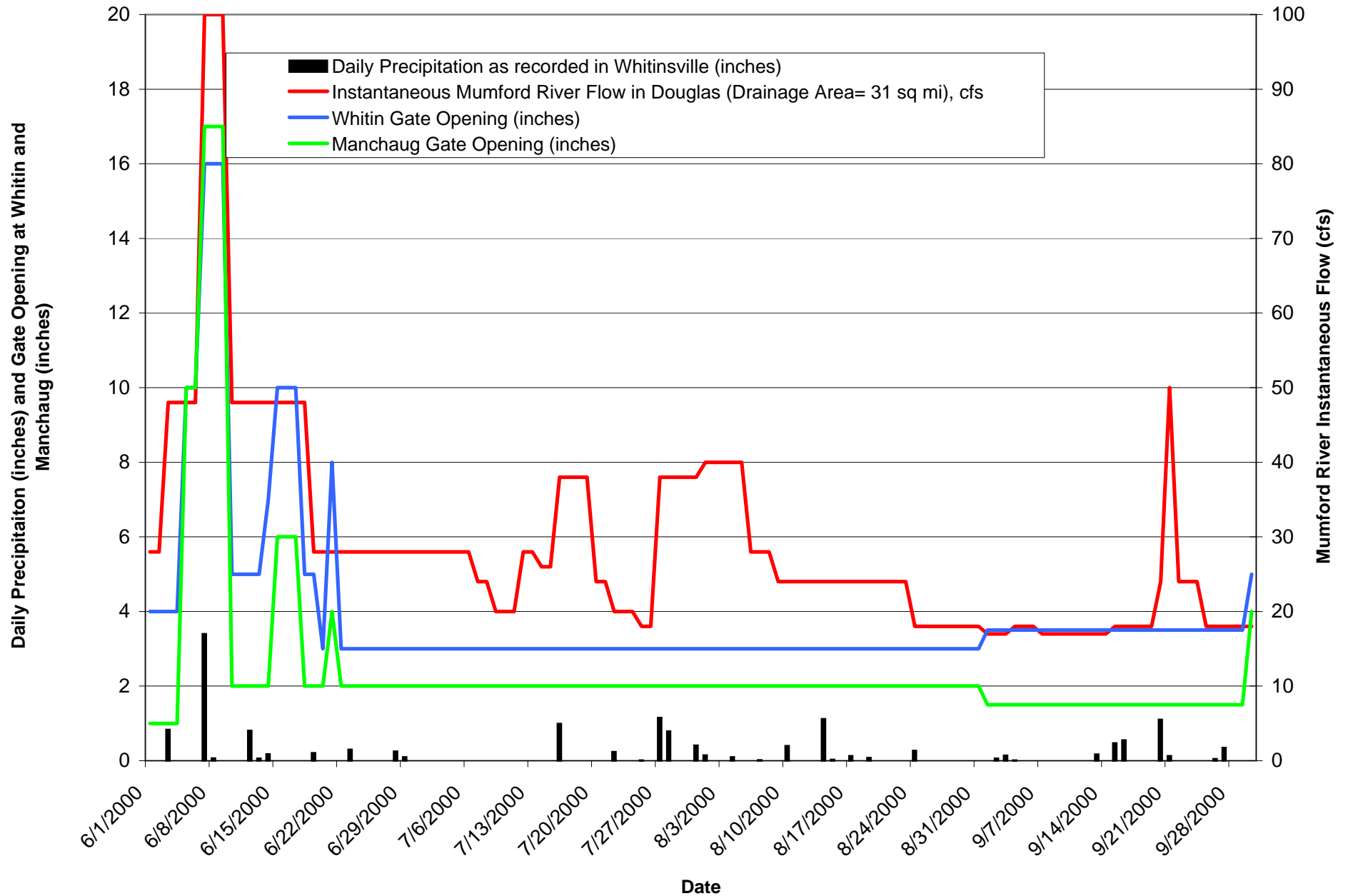


FIGURE 6.4-7

Relationship between Mumford River Flow in Douglas (as recorded by IFGF), Precipitation (as recorded in Whitinsville), and Manchaug & Whitin Reservoir Gate Openings- Calendar Year 2001

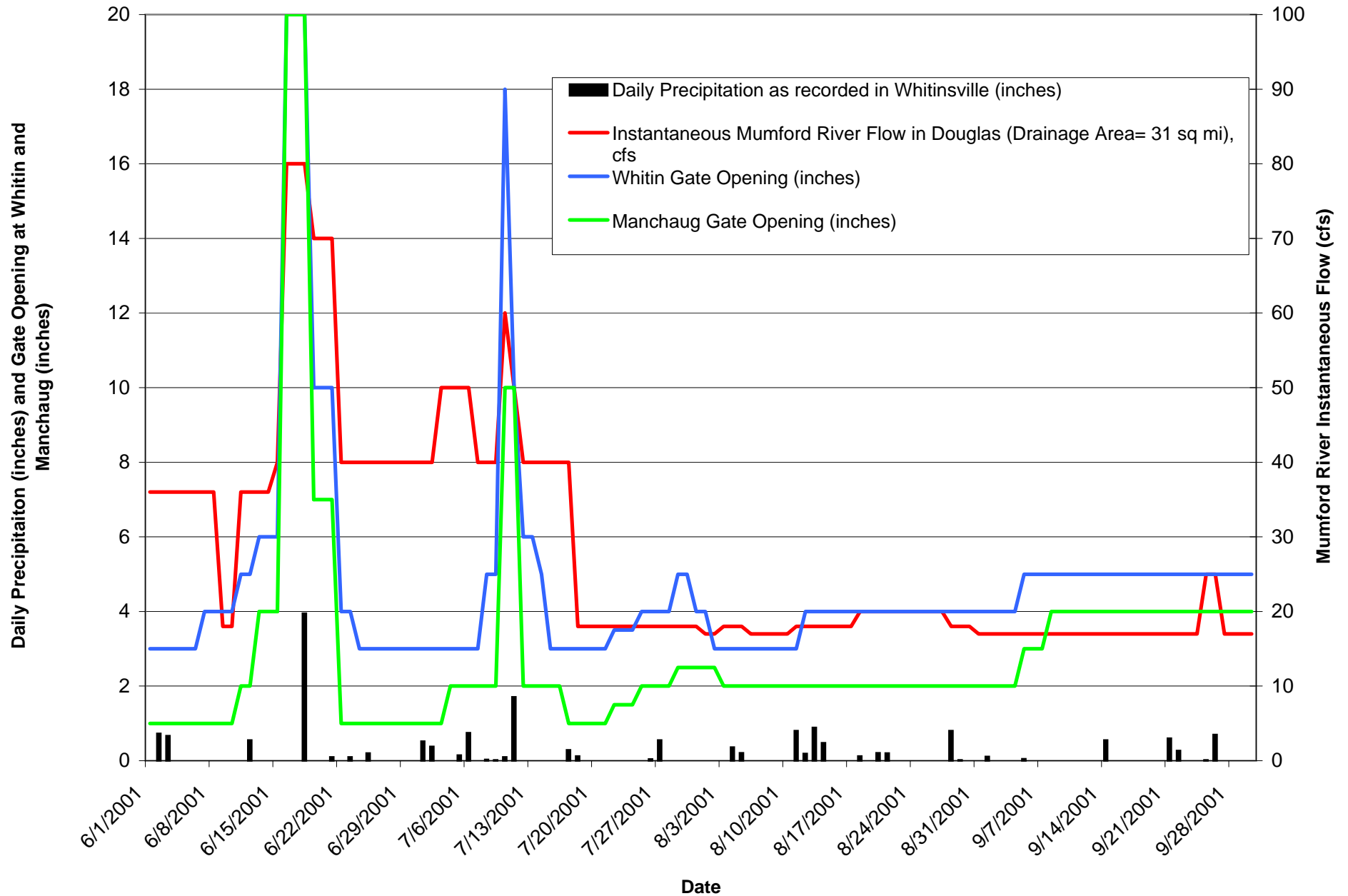


FIGURE 6.4-8

Relationship between Mumford River Flow in Douglas (as recorded by IFGF), Precipitation (as recorded in Whitinsville), and Manchaug & Whitin Reservoir Gate Openings- Calendar Year 2002

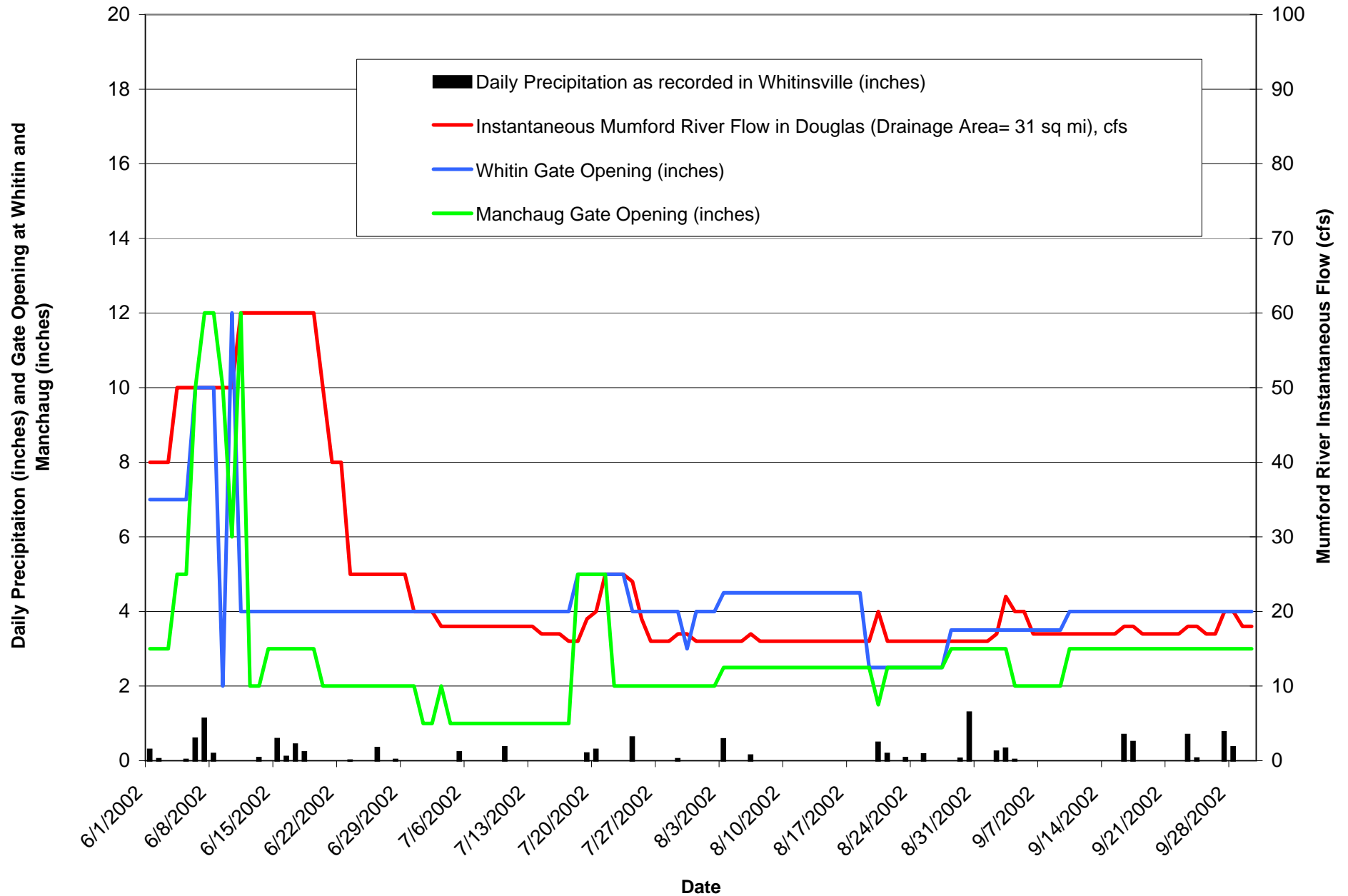
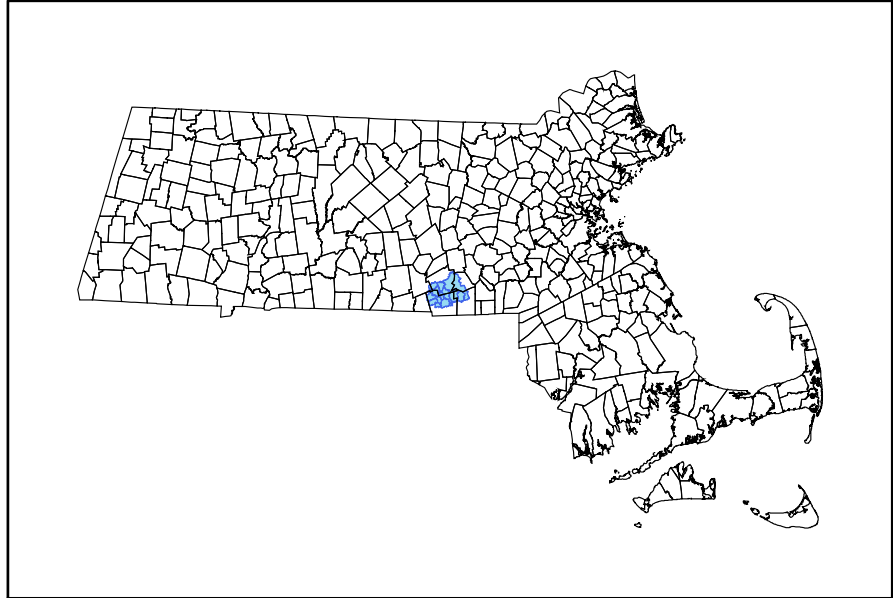


FIGURE 6.4-9

Flow Measurement Locations (Pelto Study)



N

Legend

- ▲ Flow Measurement Locations
- Dams
- ▭ Town Boundaries
- Major Lakes and Ponds
- Major Rivers and Streams
- ▨ Zone 2 Wellhead Protection Area
- ▭ Watershed Boundary
- ▨ Golf Course

0 0.5 1 2 3 4 Miles

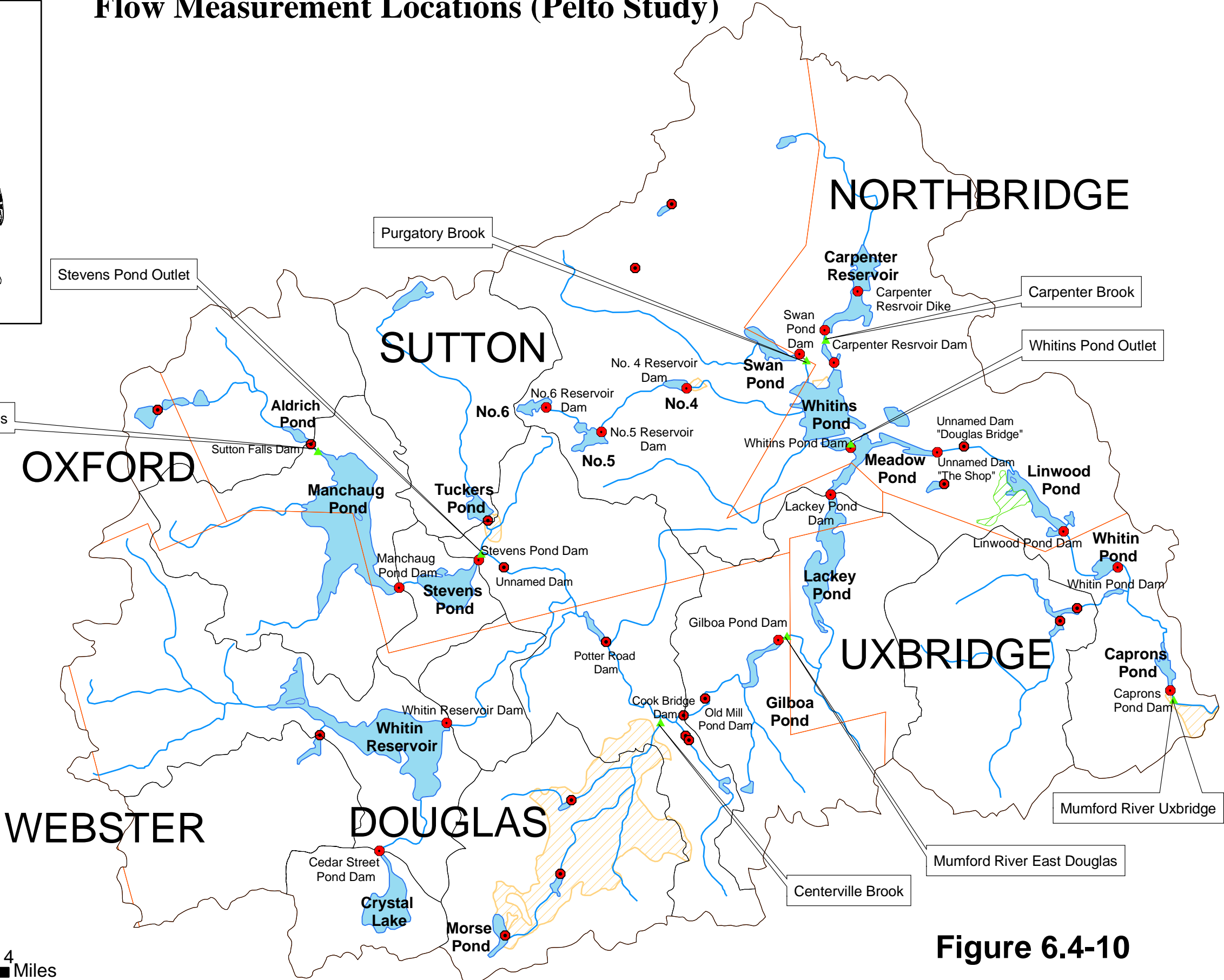


Figure 6.4-10

**Flow (cfs) Per Square Mile of Drainage for Various Sampling Locations in the Mumford River Basin
for the Dates of March 16, April 2, April 20 and May 8, 2002**

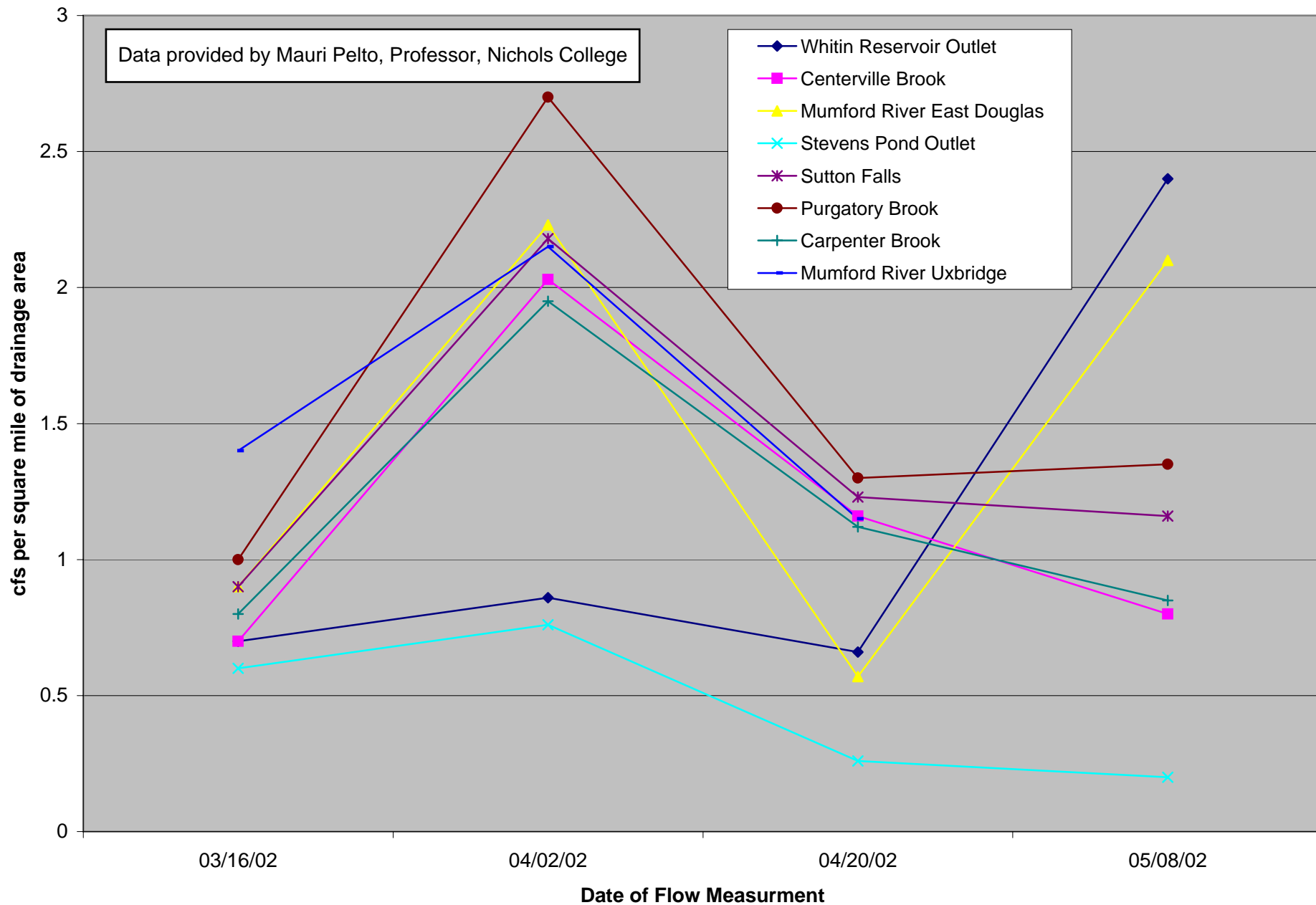


FIGURE 6.4-11

**Groundwater Levels for the Period 1984-2002 at USGS Monitoring Well Located in Whitinsville, MA
(Well No. 420610071421402)**

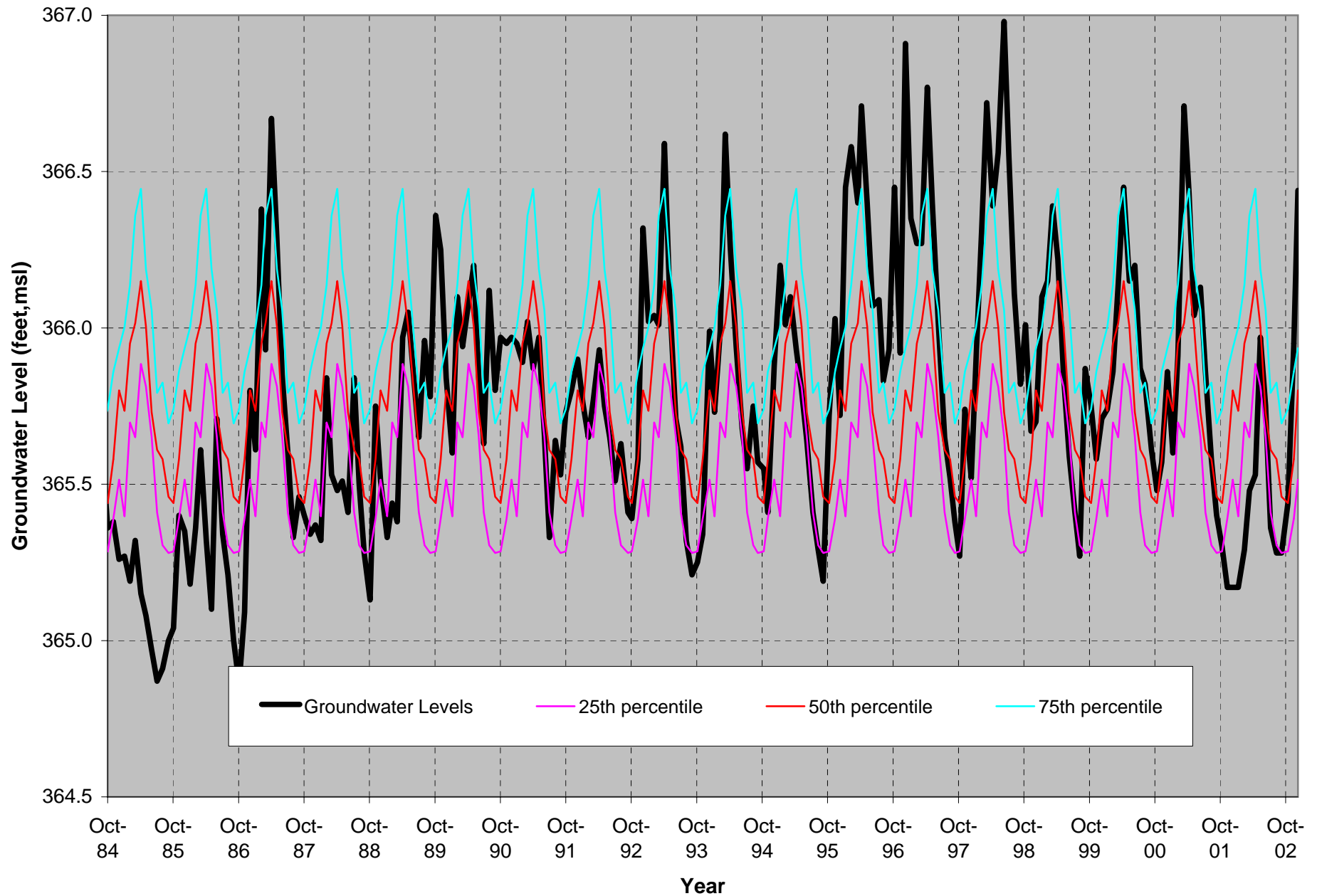


FIGURE 6.4-12

Staff Gages Located in the Mumford River Watershed

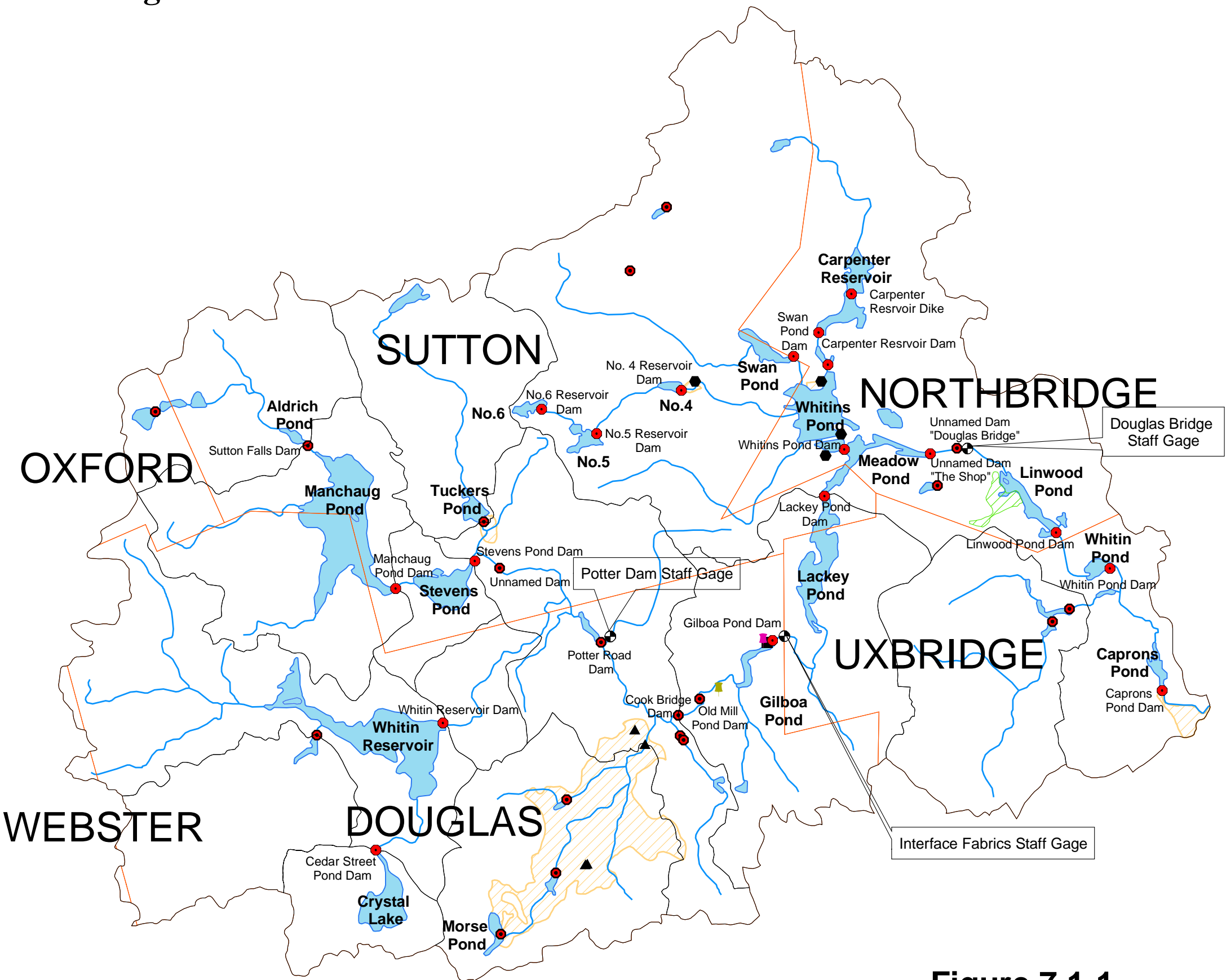
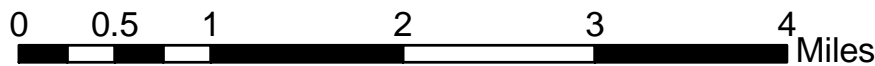
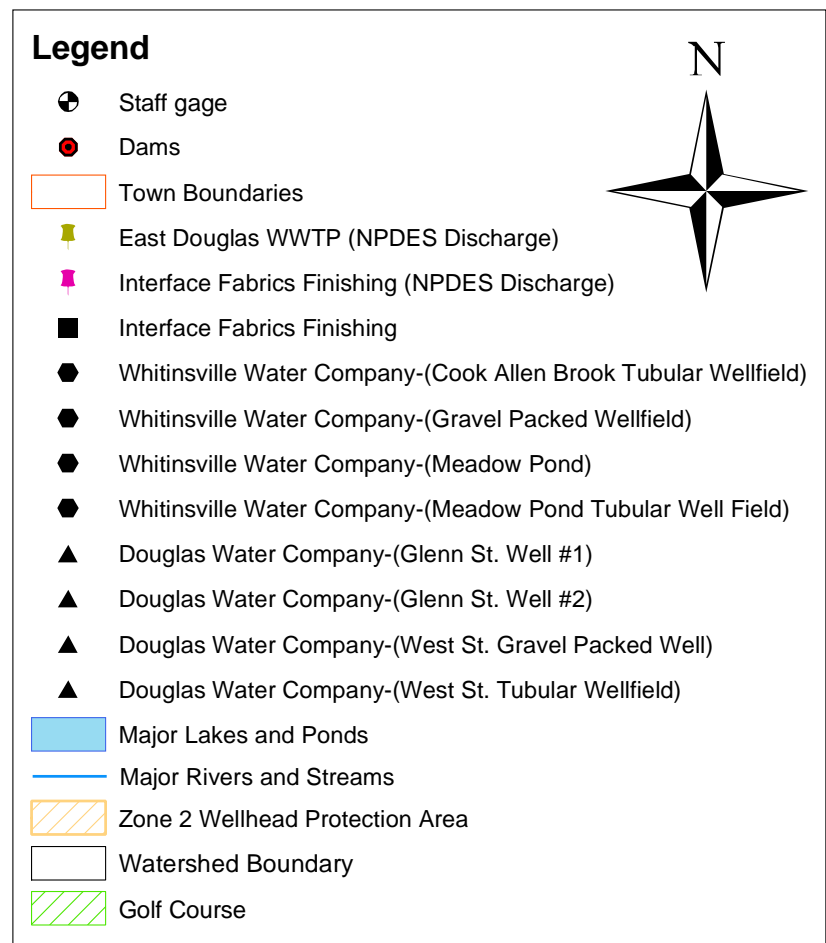
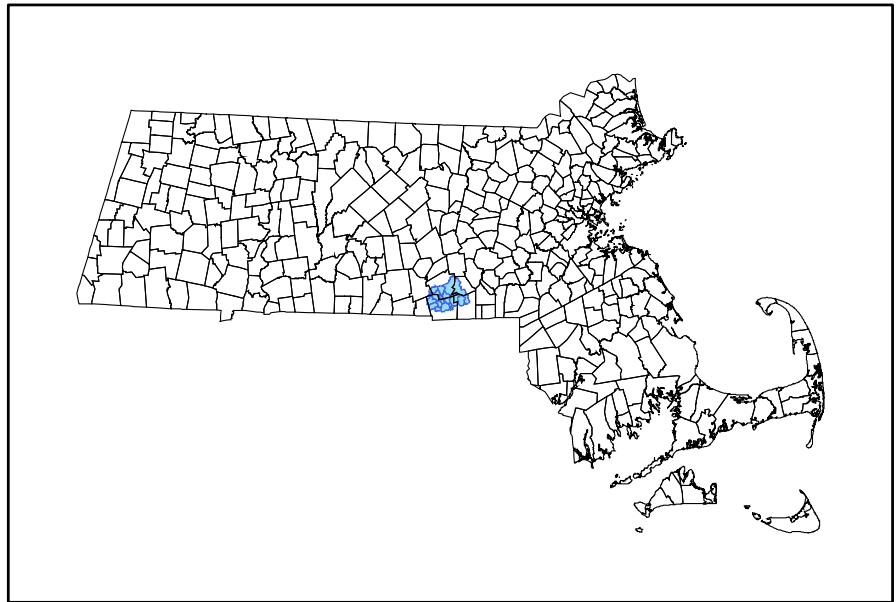


Figure 7.1-1

Potter Road Dam Staff Gage- Mumford River Rating Curve, Drainage Area= 22.6 sq mi

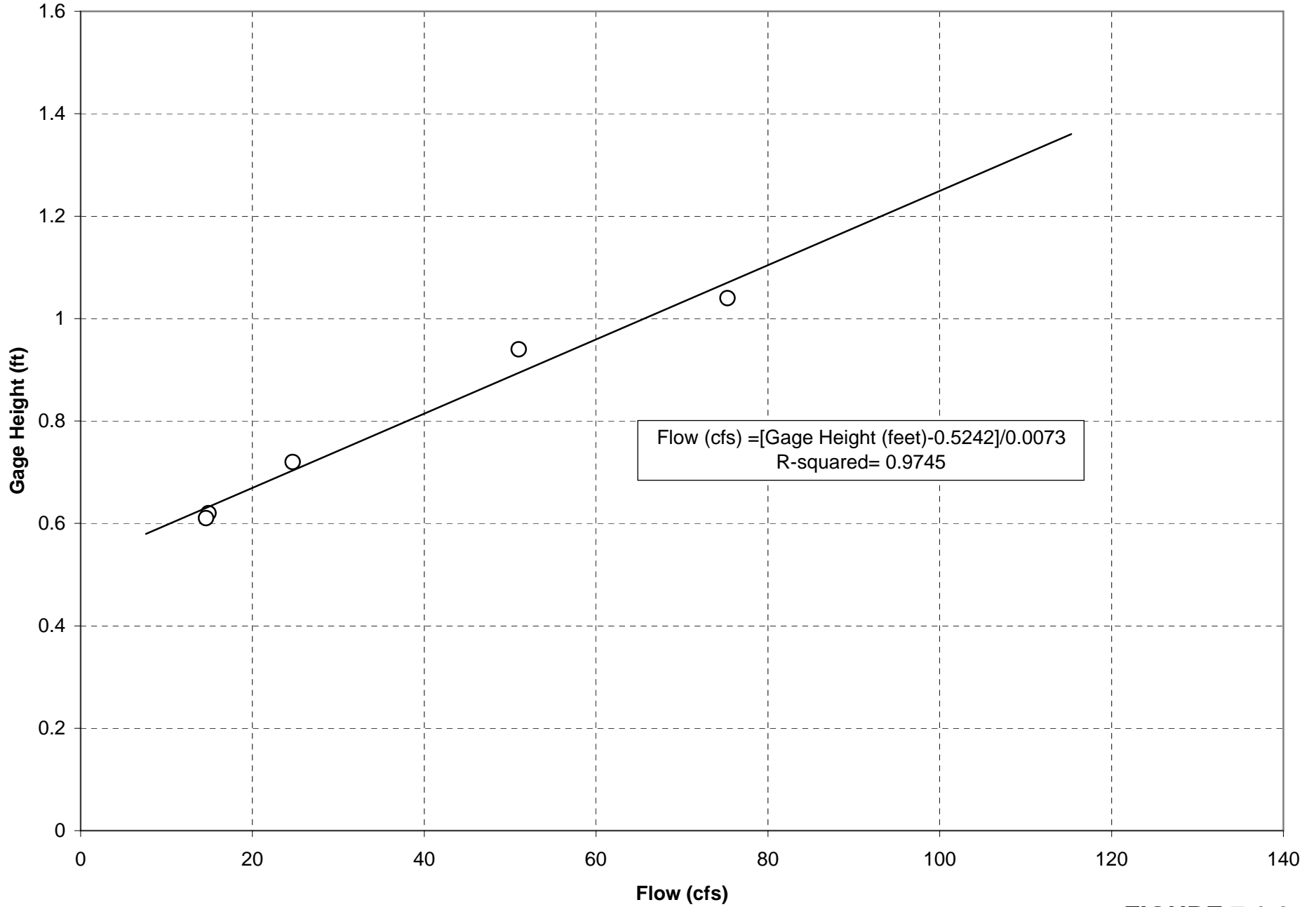


FIGURE 7.1-2

Douglas Street Dam Staff Gage- Mumford River Rating Curve, Drainage Area= 48.3 sq mi

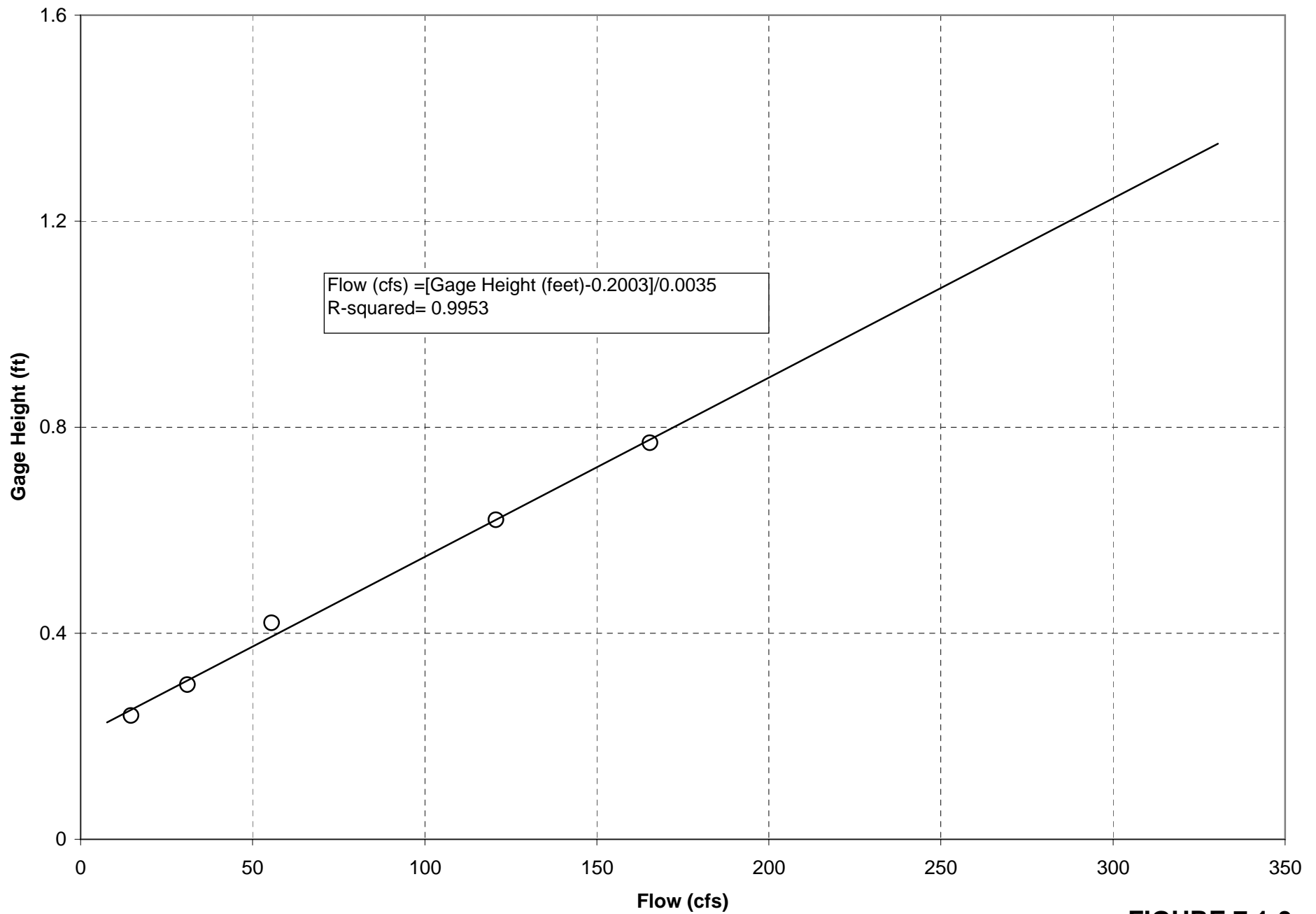


FIGURE 7.1-3

Instantaneous Flow Readings for the Mumford River at a) Potter Road Dam, b) below Gilboa Dam, and c) Douglas Street Dam for the Period 6/4-9/15, 2003 and Precipitation Totals at Whitinsville, MA

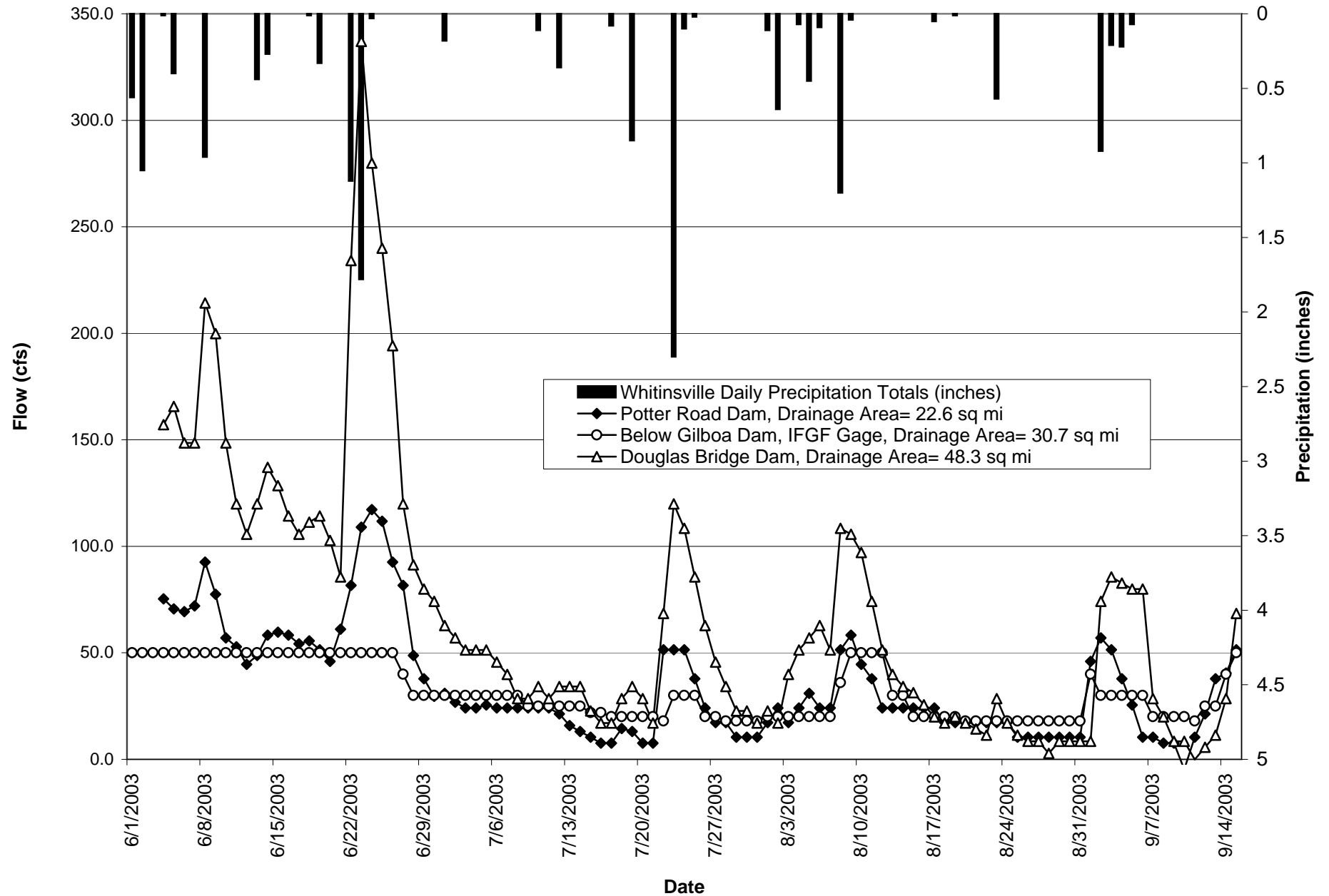


FIGURE 7.2-1

Instantaneous Flow per Square Mile Readings for the Mumford River at a) Potter Road Dam, b) below Gilboa Dam, and c) Douglas Street Dam for the Period 6/4-9/15, 2003

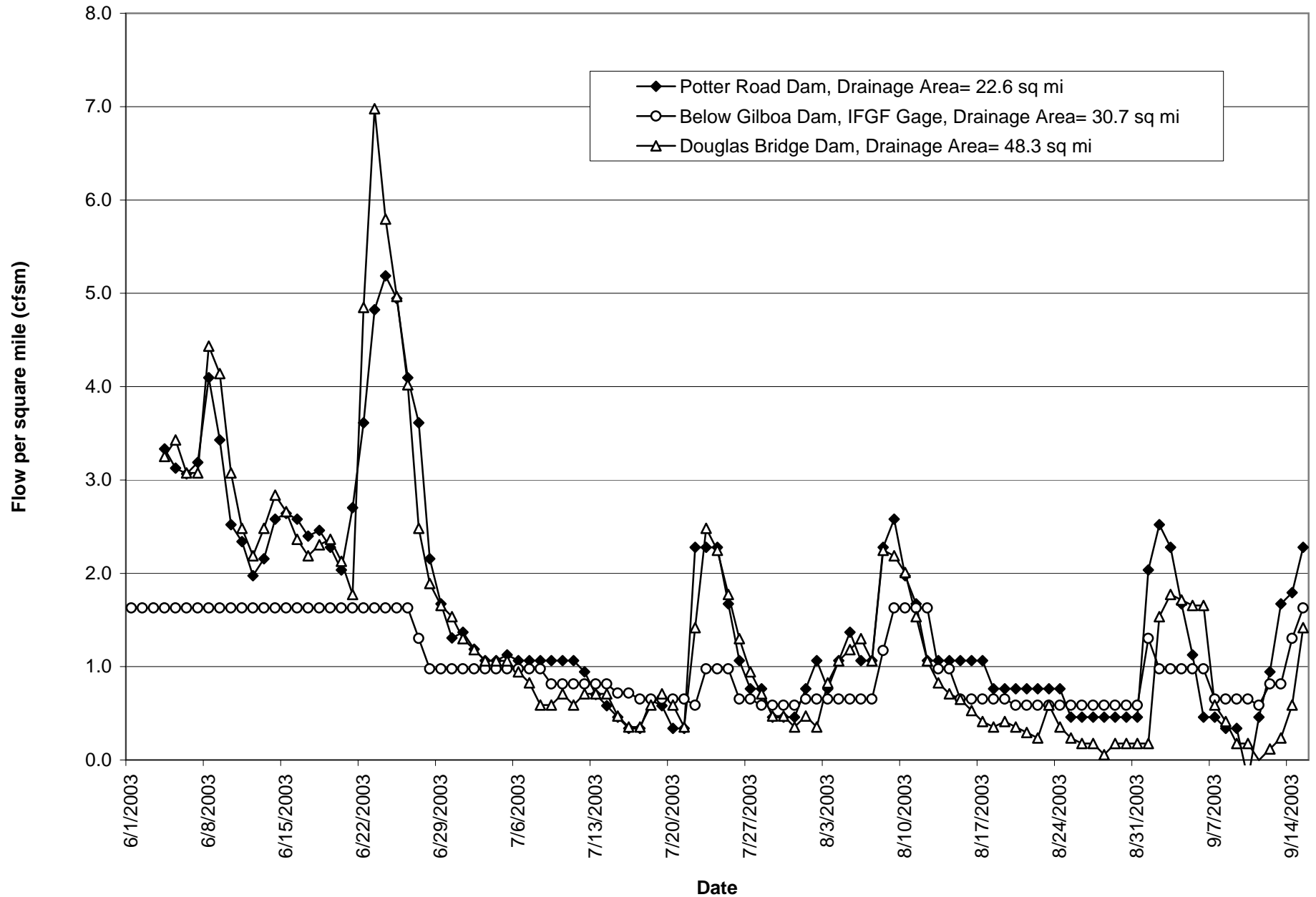


FIGURE 7.2-2

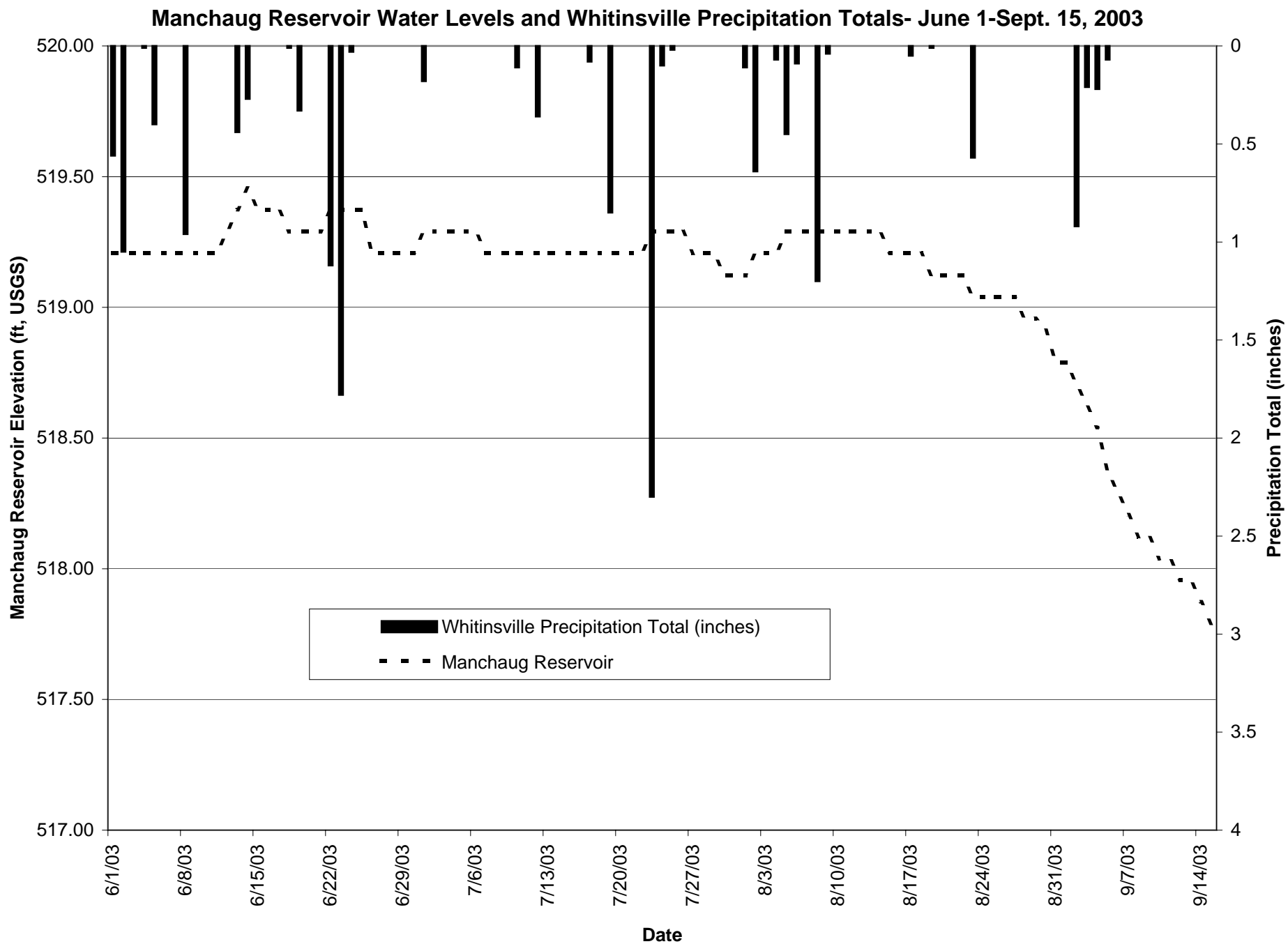


FIGURE 7.2-3

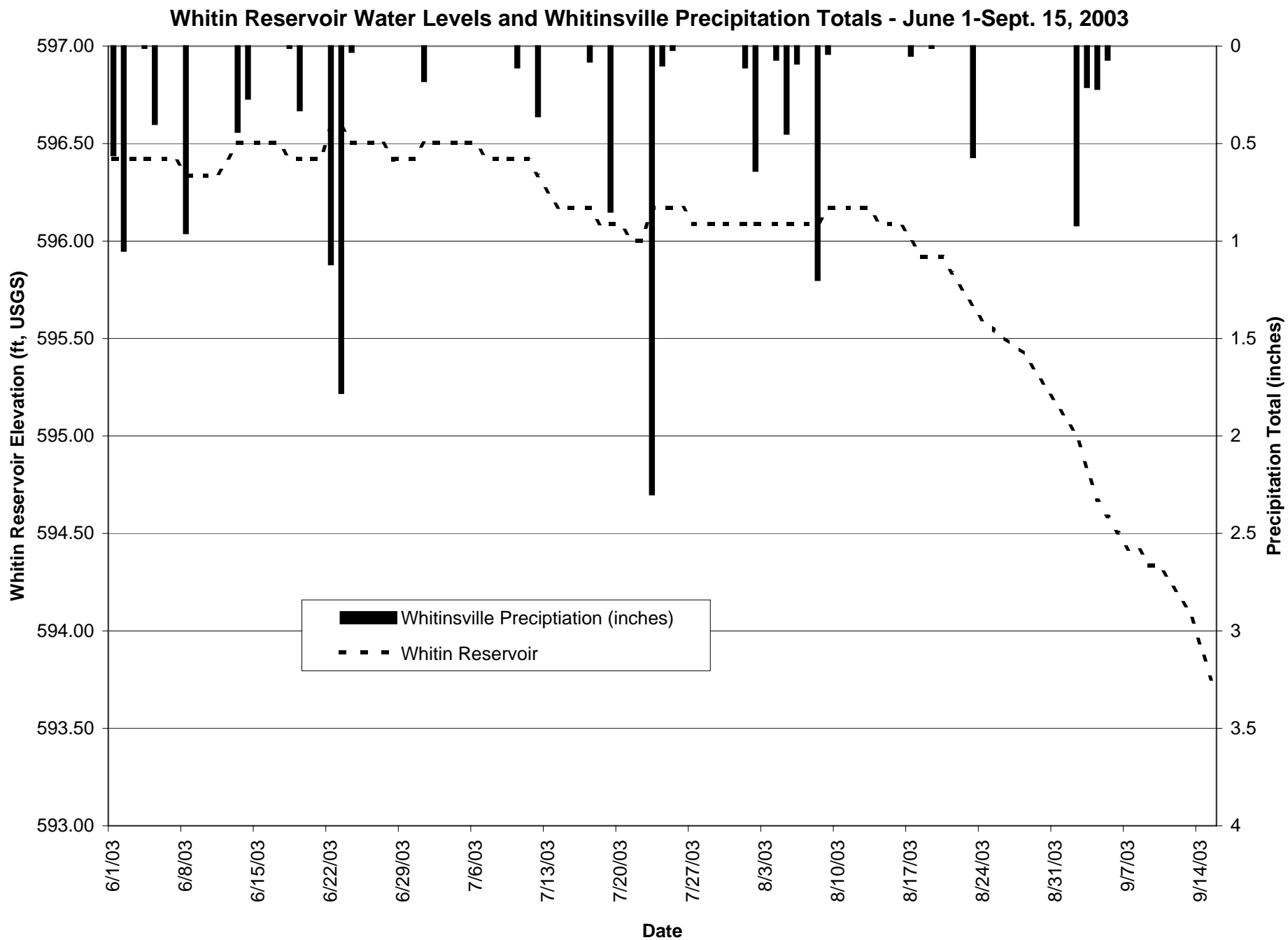


FIGURE 7.2-4

**Flow (cfs) Per Square Mile of Drainage for Various Sampling Locations in the Mumford River Basin
for the Dates of June 4, 19, July 2, July 15 & August 27, 2003**

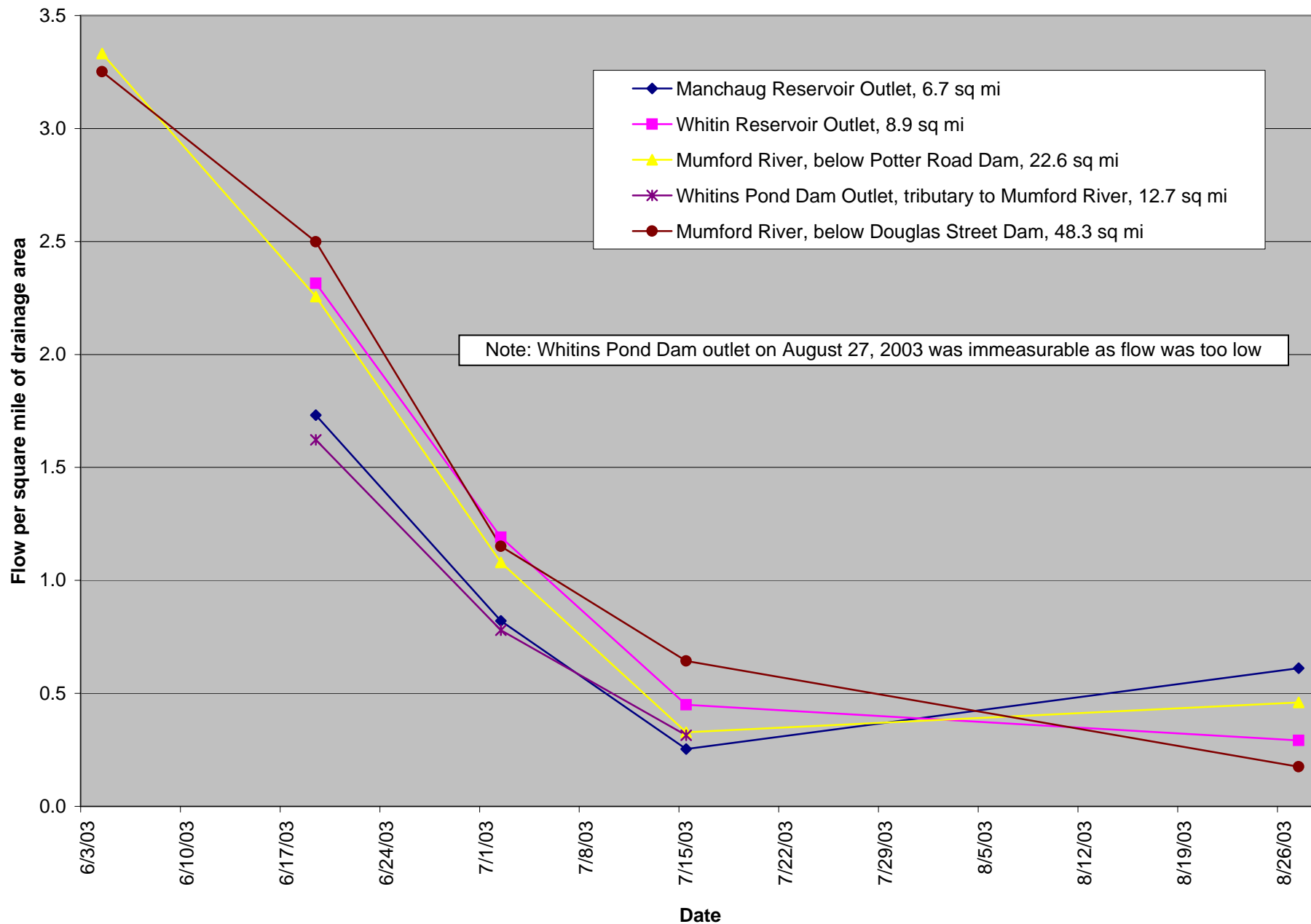


FIGURE 7.2-5